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20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

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NURSERY & LANDSCAPE

PLANT PRODUCTION

Publication 383

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Each year the appropriate sub-committee of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the sub-committee, all of these pesticides were:

- federally registered
- reviewed by the Ontario Pesticides Advisory Committee and
- classified by the Ministry of the Environment as of November, 1999.

Discard old editions of this publication.

The information in this publication is general information only. All pesticides must be used in accordance with the product label and *Regulation 914* of the Ontario *Pesticides Act.*

Pay close attention to all instructions and warnings on the pesticide label.

By printing this publication, the Ministry of Agriculture, Food and Rural Affairs does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

Policy Statement

In this publication, most recommendations list several pesticides that can be used for each pest discussed. In general:

- the least hazardous materials and those that growers have used satisfactorily for years are listed first;
- the more toxic pesticides and/or newer ones with less practical, grower experience follow.

In some cases, the most effective pesticides are highly toxic.

This publication lists a number of brand names of pesticides. This is for the grower's convenience only. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

Weather and other factors influence the effectiveness of pesticides and the likelihood of plant injury by control chemicals. Consult the package label and other information regarding compatibility with other materials, the effect of high or low temperatures, poor drying conditions, and so on. Wettable or soluble powders (WP, SP,WDG or DG) are less likely to cause plant injury than liquid concentrates (EC, SC, and F).

Health Canada has established maximum residue limits (MRLs) for pesticides. However, growers should be aware that processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market as to which restrictions or limitations apply.

Federal Registration and Provincial Classification

The Ministry of the Environment administers Ontario's *Pesticides Act* and *Regulation 914.*

All pesticides sold and used in Ontario must be:

- registered under the federal *Pest Control Products Act*, and
- classified under the provincial *Pesticides Act* by being placed in one of six schedules of the Ontario regulation.

Federal Registration

There are three federal registration categories.

1. **Full Registration**
   The federal government agrees the data package was acceptable at the time of registration.

2. **Temporary Registration**
   Additional scientific or technical information is required to obtain full registration. Temporary registrations expire after a specified time (one or two years).

3. **Temporary Registration (Restricted Class)**
   While the pesticide is urgently needed, studies on the safety of the product are incomplete. Such registrations expire on the 31st of December each year and the products must be re-registered yearly.

Provincial Classification

There are six classification schedules in *Regulation 914*. Pesticide products are classified on the basis of their toxicity, environmental or health hazard, persistence of the active ingredient or its metabolites, concentration, and usage. This system is needed to regulate the distribution, availability and use of pesticide products in Ontario.

For up-to-date information on the regulatory status of these or other pesticides contact the:

Pesticides Section,
Standards Development Branch,
Ministry of the Environment, Toronto.
Telephone (416) 327-5519

Farmer Certification

Agriculturists must be certified through the Grower Pesticide Safety Course to purchase and use Schedule 1, 2 or 5 pesticides. Effective January 1, 2000 agricultural assistants must complete Ministry of the Environment-approved training before they can handle Schedule 2 or 5 products under the supervision of a Certified Grower. Trained Assistants also have some restrictions of duties. For more information please call the Ontario Pesticide Education Program at 1-800-652-8573.

Cette publication est aussi disponible en français.

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NURSERY & LANDSCAPE

PLANT PRODUCTION

Publication 383

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Looking for pest control recommendations for woody landscape plants?

Phone the OMAFRA Nursery and Landscape Plant Agriphone Hotline
— it's udpated every Friday and it's TOLL-FREE!

1-888-290-4441 (for local calls 519-826-3414)

(or call us at 1-888-466-2372 to receive it by fax/e-mail)

Looking for nursery and landscape plant information on the Internet?

www.gov.on.ca/omafra/english/crops/hort/nursery.html

It's one-stop shopping for factsheets, articles and photos regarding the production and maintenance of woody plants.

Contents

1. Using Pesticides Safely

- General Precautions with All Pesticides 1
- Preventing Water Supply Contamination 1
- If an Accident Occurs 2
- Relative Toxicity to Applicator 2
  - Lethal Dose (LD_{50}) 2
  - Acute Toxicity 2
  - Chronic Toxicity 2
  - High Acute Toxicity 2
  - Moderate Acute Toxicity 2
  - Low Acute Toxicity 3
  - Chronic Toxicity 3
  - Entering Treated Areas 3
  - Blood Tests for those Applying Pesticides 3
  - Protective Outdoor Clothing 3
    - Why Use Personal Protection? 3
    - Reducing Exposure 4
    - Protective Clothing 4
    - Respirators 4
    - Washing Protective Clothing and Equipment 4
    - Rubber, Vinyl, or Plastic Boots and Gloves 4
    - Chemical-Resistant Clothing, Goggles, and Face Masks 5
    - Respirators 5
  - Protection for Grain Storage and Enclosed Areas 5
    - Canister Gas Masks 5
    - Self-Contained Breathing Apparatus 5
    - Other Protective Clothing 5
    - Working Conditions 5
  - Space Fumigants and Insecticide Smokes 5
    - Using Fumigants 5
- Storing Pesticides 6
  - Schedule 1, 2 and 5 Pesticides 6
  - Disposal of Containers and Contaminated Materials 7
- Sprayers 7
  - Band Spraying of Insecticides 7
  - Application by Airplane or Helicopter 7
  - Pesticide Drift 7
  - Residues on Crops to be Harvested, Fed, or Grazed 8
- Bee Poisoning 8
  - Relatively Non-Toxic to Bees 9
- New Packaging Method Available 9
  - Handling 9
  - Mixing 9
  - Compatibility 9
  - Pesticide Concentrations 9
  - Seed Treatments 10

2. Managing Soil Fertility

- The OMAFRA-Accredited Soil Testing Program 11
    - Soil Tests from Unaccredited Laboratories 11
    - Unaccredited Soil Tests 11
- Field Soil Culture 11
  - When to Sample Field Soil 11
  - How to Sample Field Soil 11
  - Field Soil Management Practices 12
  - Test Information Sheets and Soil Sample Boxes 12
  - Field Soil Micronutrient Testing 12
  - How to Sample Field Soil Micronutrients 13
- Foliar Analysis (Plant Tissue Testing) 13
  - When to Sample Plant Tissues 13
  - How to Sample Plant Tissues 13
- Soil pH Testing 13
  - Issues Surrounding pH 13
  - Buffer pH Testing 14
  - Limestone Type 14
  - Limestone Quality 14
  - Agricultural Index 14
  - Raising Soil pH 14
  - Tillage Depth 15
  - Lowering Soil pH 15
  - Soluble Salts in Soil 15
- Organic Amendments to Soil 16
  - Applying Manure 16
  - How to Sample Manure 16
- Fertilizing 16
  - Fertilizing Field Nursery Stock 16
  - Fertilizing Seed Beds and Transplant Liner Beds 17
- Fertilizing Established Field Stock 17
- Fertilizer Application Rates 18
- Nursery Container Culture 19
  - Using Pots 19
  - Using Potting Mixes 19
  - Using Soilless Media 19
  - Determining Potting Mix Porosity 19
  - Adjusting Potting Mix pH 20
  - Fertilizing Container Stock 20
  - How to Sample and Test Container Soils 21
  - Using Water Soluble Fertilizers 21
  - Using Controlled Release Fertilizers 21
  - Measuring Nutrient Levels of Container-Grown Crops 22
  - Fertilizer Application Rates 22
  - Fertilizing Landscape Plantings 22

3. Insects and Diseases

- Insects and Mites Affecting Trees and Shrubs 24
- Defoliators 25
  - Caterpillars 25
  - Leaf Eating Beetles 25
  - Leafminers and Casebearers 25
  - Sawflies 25
- Sucking Insects 26
  - Aphids 26
  - Leafhoppers 26
  - Mites 26
  - Thrips 26
  - Plant Bugs 26
  - Scales 26
    - Armoured scales 27
    - Soft scales 27
    - Mealybugs 27
- Borers 27
- Gall Makers 27
- Soil Pests 27
  - Japanese Beetles 27
    - Managing Japanese Beetles in Nurseries 27
  - Nematodes 28
    - Soybean cyst nematode 28

- Ontario Insect Calendar ... 29
- Diseases Affecting Trees and Shrubs ... 32
  - Foliage Diseases ... 32
    - Botrytis (Grey Mold) ... 32
    - Downy Mildew ... 32
    - Powdery Mildew ... 32
    - Leaf Spot and Anthracnose ... 32
    - Needlecast ... 32
    - Scab ... 33
    - Apple Scab ... 33
    - Pyracantha scab ... 33
  - Crown and Root Rots ... 33
  - Cankers ... 33
  - Rust ... 33
  - Fire Blight ... 33
  - Crown Gall ... 34
  - Vascular Wilts ... 34
  - Virus Diseases ... 34
    - Ash yellows ... 35
    - Elm yellows ... 35
    - Rose mosaic ... 35
  - Abiotic Diseases ... 35
    - Understanding Dieback ... 35
    - Fall Needle Drop of Conifers ... 35
    - Needle Browning on Conifers ... 35
    - Salt Damage ... 35
    - Salt Damage Symptoms on Conifers ... 36
    - Salt Damage Symptoms on Deciduous Plants ... 36
    - Scorch ... 36
- Treating Tree and Shrub Pests with Insecticides and Fungicides ... 36
  - Toxicity Information ... 36
- Chemical Families ... 36
- Pesticide Application Restrictions ... 36
- **Pesticides Used to Protect Ornamentals ... 37**

A Compendium of Pests and Diseases with Recommended Treatments — 2000

- ABIES — fir ... 39
- ACER — maple ... 39
- AESCULUS — horse chestnut ... 41
- BETULA — birch ... 41
- BUXUS — boxwood ... 42
- CARYA — hickory ... 42
- CATALPA — catalpa ... 42
- CHAENOMELES — quince ... 42
- CRATAEAGUS — hawthorn ... 43
- CORNUS — dogwood ... 43
- EUONYMUS — euonymus ... 43
- FAGUS — beech ... 44
- FORSYTHIA — forsythia ... 44
- FRAXINUS — ash ... 44
- GLEDITSIA — honey locust ... 45
- HYDRANGEA — hydrangea ... 46
- JUGLANS — butternut walnut ... 46
- JUNIPERUS — juniper ... 46
- LARIX — larch ... 47
- LIGUSTRUM — privet ... 47
- LIRIODENDRON — tuliptree ... 48
- LONICERA — honeysuckle ... 48
- MAGNOLIA — magnolia ... 48
- MALUS — apple ... 49
- PACHYSANDRA — pachysandra ... 50
- PICEA — spruce ... 50
- PINUS — pine ... 52
- PLATANUS — London plane, Sycamore ... 55
- POPULUS — poplar ... 55
- PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum ... 56
- PSEUDOTSUGA — Douglas Fir ... 57
- PYRACANTHA — firethorn ... 57
- PRYUS — pear ... 57
- QUERCUS — oak ... 57
- RHODODENDRON — rhododendron ... 58
- ROBINIA — locust ... 59
- ROSA — rose ... 59
- SALIX — willow ... 60
- SORBUS — mountain ash ... 61
- SYRINGA — lilac ... 61
- TAXUS — yew ... 62
- THUJA — eastern white cedar, arborvitae ... 63
- TILIA — linden, basswood ... 64
- TSUGA — hemlock ... 64
- ULMUS — elm ... 64
- VIBURNUM — virburnum ... 65

4. Rodents and Deer

- Vole (Mouse) Control ... 66
  - Vole Control Options ... 66
  - Precautions for Handling Poison Baits ... 66
    - It's important to handle poison baits safely ... 66
    - Examples of bait stations ... 66
- Rabbit Control ... 67
  - Rabbit Control Options ... 67
- Deer Control ... 67
  - Deer Control Options ... 67

5. Controlling Weeds

- Weed Control Principles ... 69
- Reducing Weeds Before Planting ... 69
  - Cover Crops ... 69
  - Controlling Perennial Weeds ... 69
  - Crop Rotation ... 69
  - Stale Seedbeds ... 70
  - Preparing Container Beds ... 70
  - Eliminating Weed Sources ... 70
- Mechanical Weed Control ... 70
  - Rotary Hoes ... 70
  - Inter-Row Cultivation ... 71
  - Mowing ... 71
- Managing Herbicide Resistance ... 71
  - Delaying Herbicide Resistance ... 71
- Chemical Weed Control ... 72
  - Herbicide Licensing Requirements ... 72
  - Applying Chemical Herbicides ... 72
  - Herbicide Drift ... 72
    - To minimize drift: ... 72
    - General Precautions ... 72
- When To Use Herbicides ... 73
  - Application Technology ... 73
    - New Technologies ... 73
    - Sprayers for Home Use ... 73
    - Field Sprayers ... 73
    - Air Blast or Mist Sprayers ... 73
    - Wiper Applicators for Selective Weed Control ... 73
- Equipment Use and Care ... 73
  - Spraying Speeds ... 73
  - Using Water Correctly ... 73

  Agitation 74
    Preparing a Wettable Powder and Oil or Emulsifiable Concentrate Mix 74
  Pumps 74
  Nozzles 74
    Flat-Fan Nozzle Tips 75
    Flooding-Fan Nozzle Tips 75
    Broadcast Nozzle Tips 75
    Full and Hollow Cone Nozzle Tips 75
    Nozzle Screens 75
  Cleaning the Sprayer 75
    Environmental Issues when Cleaning 75
Sprayer Calibration 76
  Determining Application Rates in L/ha 76
    Method 1: 76
    Method 2: 76
  Sample Calibration Calculations 77
    Overall Spraying 77
    Band Spraying 77
  Determining the Number of Hectares Per Tankful 77
  Calibrating Hand-Held and Backpack Sprayers 77
    Method 1: 77
    Method 2: 78
  Determining the Herbicide Quantity Required 78
Materials, Mixing, and Mixtures 78
  Dry Formulations 78
  Liquid Formulations 78
  Mixing Herbicide Formulations 78
  Application Indicators 79

A Compendium of Herbicides with their Recommended Uses in Ontario — 2000

Preplanting Treatments 79
  dazomet 80
  BASAMID 80
    Dithiocarbamate 80
  metam sodium 80
  VAPAM 80
    Thiocarbamate 80
  methyl bromide /chloropicrin 81
  TERR-O-GAS 81
    Organohalogen 81
  methyl isothiocynate/dichloropropene 81
  VORLEX PLUS, VORLEX PLUS CP 81
    Thiocarbamate 81
Preemergence Treatments 82
  chloropropham 82
  CIPC, CIPC EC, CIPC GR 82
    Phenylcarbamate 82
  dichlobenil 83
  CASORON 83
    Benzonitrile 83
  napropamide 83
  DEVRINOL 10G, DEVRINOL 50 DF, DEVRINOL 50 W 83
    Amide 83
  oxadiazon 84
  RONSTAR 2G 84
    Oxadiazole 84
  propyzamide 85
  KERB 85
    Amide 85
  simazine 85
  PRINCEP NINE-T, SIMADEX, SIMAZINE, SIMAZINE 480 85
    S-triazine 85
  s-metolachlor 86
  DUAL MAGNUM 86
    Acetanilide 86
  trifluralin 87
  BONANZA, RIVAL, TREFLAN 87
    Dinitroaniline 87
Post-Emergence Treatments 87
  fluazifop-p-butyl 87
  FUSILADE II 87
    Aryloxyphenoxypropionate 87
  glyphosate 88
  CLEAR-IT 1, CLEAR-IT 2, CLEAR-IT 3, EXPEDITE, GRASS & WEED, ROUNDUP 88
    Amino acid 88
  paraquat 89
  GRAMOXONE 89
    Bipyridylium 89
Herbicides Registered in Ontario 90

Appendices

A. Ontario Ministry of Agriculture, Food and Rural Affairs Advisory Staff 97
B. Ontario Ministry of the Environment Pesticide Control Offices 97
C. Accredited Soil Testing Laboratories in Ontario 98
D. Other Contacts 98
E. Diagnostic Service 99
  How to Sample for Nematodes 100
  Submitting Plant for Disease Diagnosis or Identification .. 100
  Submitting Insect Specimens for Identification 100
F. The Metric System 101

Index 103
Spraying Record

Colour Plates

Tables

TABLE 1–1. Safety Supply Companies in Ontario Providing Protective Clothing or Respiratory Devices 6
TABLE 1–2. Relative Toxicity of Insecticides to Honeybees 9
TABLE 2–1. OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories 12
TABLE 2–2. Average Foliar Nutrient Content of Healthy Nursery Stock 13
TABLE 2–3. Lime Requirements to Correct Soil Acidity Using Buffer pH 14
TABLE 2–4. Soil Acidification to pH 5.0 Using Sulphur 14
TABLE 2–5. Soil Conductivity Readings 15
TABLE 2–6. Manure Application Rate and Nutrient Adjustment Guidelines 16
TABLE 2–7. Phosphorus Requirements for New and Established Field Nursery Stock 17
TABLE 2–8. Potassium Requirements for New and Established Field Nursery Stock 17
TABLE 2–9. Nitrogen Sources 18
TABLE 2–10. Phosphorus Sources 18
TABLE 2–11. Potassium Sources 18
TABLE 2–12. Nitrogen Equivalency Table 18
TABLE 2–13. Nutrient Levels for Most Container Crops 23
TABLE 3–1. Symptoms and Possible Causes of Insect Injury (by plant injury) 24
TABLE 3–2. Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter) 25
TABLE 3–3. April Insect Calendar 29
TABLE 3–4. May Insect Calendar 29
TABLE 3–5. June Insect Calendar 30
TABLE 3–6. July Insect Calendar 30
TABLE 3–7. August Insect Calendar 31
TABLE 3–8. September Insect Calendar 31
TABLE 3–9. Woody Plants Susceptible to Verticillium Wilt 34
TABLE 3–10. Woody Plants Resistant to Verticillium Wilt ... 34
TABLE 3–11. Chemical Families 36
TABLE 3–12. Insecticides and Fungicides Used to Protect Ornamentals (by Product Name) 37
TABLE 3–13. Pesticide Schedules 38
TABLE 4–1. Rodenticides 67
TABLE 5–1. Herbicides Registered in Ontario (by Trade Name) 79
TABLE 5–2. Herbicides Registered in Ontario (by Common Name) 79
TABLE 5–3. Herbicide Label and Plant Restrictions........... 90
TABLE 5–4. Herbicides Registered for use on Woody Plants 90
TABLE 5–5. Weed Susceptibility and Herbicides — Broadleaf Annuals 93
TABLE 5–6. Weed Susceptibility and Herbicides — Broadleaf Perennials 94
TABLE 5–7. Weed Susceptibility and Herbicides — Annual Grasses 95

1. Using Pesticides Safely

Pesticides can be dangerous. Before opening any pesticide container, always read the entire label. Follow all directions to the letter and observe all stated precautions scrupulously.

General Precautions with All Pesticides

1. Keep a record of the common names of all the pesticides you handle, especially those listed as hazardous in this publication. Other members of your family need to know about this list in case there is an accident.

2. Never smoke, chew tobacco, or eat while handling or applying pesticides. Do not carry tobacco or food in clothes worn while spraying. Change your clothes and wash before eating.

3. When handling and mixing pesticide concentrates, rinsing empty containers, or repairing leaks, wear a full set of protective clothing. This includes a waterproof cap, coveralls, impervious gloves and boots, and safety goggles. If you are using highly or extremely toxic pesticides or very dusty formulations, wear a respirator. If you are handling dusty formulations, wear a dust mask. If you are handling volatiles or gases, you must wear a respirator. If these gases are highly dangerous or you are handling them in an enclosed space, you may need a self-contained breathing apparatus. Make sure you follow the specific instructions on the pesticide label

4. When you draw water from wells, ponds, streams, or other sources, use an anti-backflow device to prevent back-siphoning. Mix pesticide at least 50 m from wells, ponds, or streams. Triple or pressure rinse the empty container and add the rinse water to the tank. Only mix enough solution to do the spray job. When you have finished loading and mixing, wash down your gloves and boots with clean water before removing them.

5. During application, a tractor cab with charcoal filter gives adequate protection against exposure. Wear impervious gloves, boots, coveralls, and cap when tending to stoppages. When using airblast and mist blowers, or in tractors without cabs, wear waterproof suits and caps and impervious gloves and boots. When applying fumigants in the field, have a respirator on hand in case you need to deal with equipment problems or in case inadequate sealing in the soil allows the fumigant to escape.

6. When the spray operation is done, bathe or shower to remove pesticide deposits on your skin. Do not handle anything in your home before you bathe.

For more information on pesticide use and safety, see the *OMAFRA/Agriculture and Agri-Food Canada* booklet *Pesticide Storage, Handling, and Application.*

Preventing Water Supply Contamination

Pesticides can contaminate well, pond, and surface water. It is an offence to contaminate surface waters with pesticides. Taking the following steps will help prevent contamination:

- Keep pesticide concentrates above the flood plain in locked storage.

- After emptying, triple or pressure rinse, crush, and dispose of containers.

- Return empty plastic or metal containers to a dealer who participates in the container recycling program.

- Mix concentrate and water at least 50 m away from any water supply.

- Use buffer zones and berms to avoid contaminating surface water, wells, ponds, and streams.

- Do not use drinking water sources to fill spray equipment. If you fill your tank from a well, lake, river, or other surface water source, you must use an anti-backflow device.

If an Accident Occurs

1. Wash your gloves, boots, and respirator before removing them. Take off your clothing, including underclothes, immediately and wash contaminated skin thoroughly with soap and water. Soak clothes immediately and double launder them as soon as possible. If the spill was serious, place the clothes in a plastic bag and dispose of them in a safe manner. Wash your gloves, boots, and respirator again.

2. If clothing becomes wet with a pesticide, remove it immediately, wash, and put on fresh clothes.

3. If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital. Take your list of common-name chemicals with you. (See *Emergency Procedures for Pesticide Poisoning* on the inside back cover.)

4. Clean up any pesticide spills immediately. In the case of minor spills, use dry soil or other absorbent material (such as kitty litter) to remove excess liquid. Sweep up powders and granulars. Contaminated soil and sweepings should be spread over a large area of bare soil to facilitate rapid degradation. Make sure you are adequately protected when cleaning up the spill.

5. For information on preventing spills see OMAFRA Factsheet *Ways to Avoid Pesticide Spills*, Order No. 96-025.

6. **In the case of a major pesticide spill, you must notify the *Ministry of the Environment and Energy, Spills Action Centre*, 5775 Yonge St., Suite 1005, North York, Ontario, M2M 4J1. Telephone (416) 325-3000 or (800) 268-6060.**

7. If a well becomes contaminated, follow the cleanup instructions in OMAFRA Factsheet *Pesticide Contamination of Farm Water Supplies*, Order No. 86-077.

8. **See the inside back cover of this publication for *emergency procedures* and first aid in the event of pesticide poisoning.**

Relative Toxicity to Applicator

Learn about the health hazards and toxic properties of the pesticide you are using.

Lethal Dose (LD$_{50}$)

The dose that, when administered to test animals, will kill 50% of the test animals within a stated period.

Acute Toxicity

Immediate adverse effects from a single or short period of exposure to a substance via the oral, dermal, and/or inhalation routes.

Chronic Toxicity

Adverse effects resulting from repeated exposure to a substance over an extended period.

High Acute Toxicity

These pesticides are extremely dangerous if handled carelessly! The acute oral LD$_{50}$ is less than 50 mg/kg of body weight, and the acute dermal LD$_{50}$ is less than 200 mg/kg body weight. These pesticides can be fatal if you ingest or absorb less than 0.1–3.0 mL (one drop to half a teaspoon). These pesticides are labeled with the skull and crossbones in a stop sign. ***You must use a respirator and eye protection along with all other protective clothing when using these products:***

- **azinphos-methyl (Guthion, Sniper)**
- **disulfoton (Di-Syston)**
- **endosulfan (Endosulfan, Thiodan)**
- **fonofos (Dyfonate II)**
- **methomyl (Lannate)**
- **phorate (Thimet)**
- **terbufos (Counter)**
- **terbufos + phorate (Cygard)**

Moderate Acute Toxicity

These pesticides are dangerous if handled carelessly. The acute oral LD$_{50}$ is 50–500 mg/kg of body weight, and the acute dermal LD$_{50}$ ranges from about 200–2,000 mg/kg body weight. These pesticides can be fatal if you ingest or absorb as little as 3–30 mL (½ tsp–2 tbsp). These pesticides are labeled with the skull and crossbones on a stop sign.

- **chlorpyrifos (Lorsban)**
- **deltamethrin (Decis)**
- **dimethoate (Cygon, Lagon)**
- **phosmet (Imidan)**
- **tefluthrin (Force)**

Wear a respirator when using these products.

Low Acute Toxicity

These pesticides are not fatal unless deliberately ingested in amounts of over 30 mL (1 oz.). The acute oral LD_{50} is greater than 500 mg/kg body weight, and the acute dermal LD_{50} is greater than 2,000 mg/kg body weight.

Pesticides listed in this publication *and not listed in this section* have low acute toxicities. You should handle them with caution. You must wear protective clothing. You should wear safety goggles, and if using these products in a confined space, you should use a respirator.

Learn about the health hazards and toxic properties of the pesticide you are using.

Chronic Toxicity

It is not possible to assess chronic toxicity of a pesticide in the same way a LD_{50} is used to determine acute toxicity. Instead, a number of tests performed on animals help predict whether a pesticide may cause long-term effects. Animals are examined for a wide variety of toxic effects such as the production of tumors or abnormalities. Using protective clothing and equipment will help reduce exposure and the risk of chronic effects.

Entering Treated Areas

Workers may be poisoned if they enter fields without wearing protective equipment too soon after pesticides have been applied. Such poisoning can result from handling treated plants or from inhaling pesticide vapours.

The list below shows a specific minimum interval that you must observe between applying pesticide and working in the crop without protective equipment. Some pesticides, like *parathion*, have labels that carry a warning about working in treated crops. Follow the label's recommendations. Otherwise, keep to the following minimum intervals:

24 hours	48 hours
methomyl (Lannate)	azinphos-methyl (Guthion, Sniper)
methidathion (Supracide)	carbofuran (Furadan)

If prolonged direct contact with corn foliage will occur, do not enter treated fields within 14 days of application without wearing protective equipment.

Blood Tests for those Applying Pesticides

Organophosphorus and *carbamate* pesticides can inactivate serum and red blood cholinesterase levels. If cholinesterase activity falls below a critical level, poisoning can result. Symptoms include fatigue, dizziness, nausea, trembling, blurred vision, and difficulty breathing. If you plan to use these pesticides, have your family doctor check your cholinesterase levels. *Start the blood tests before beginning to use any of these pesticides* — normal levels can vary considerably, making it difficult to assess the degree of suppression. In this publication, the insecticides of primary concern are:

- **azinphos-methyl** (Guthion, Sniper)
- **carbaryl** (Sevin)
- **chlorpyrifos** (Lorsban)
- **dimethoate** (Cygon, Lagon)
- **disulfoton** (Di-Syston)
- **fonofos** (Dyfonate)
- **methomyl** (Lannate)
- **phosmet** (Imidan)
- **phorate** (Thimet)
- **terbufos** (Counter)
- **terbufos + phorate** (Cygard)
- **trichlorfon** (Dylox)

Protective Outdoor Clothing

Why Use Personal Protection?

Pesticide formulations vary in toxicity from slightly to extremely poisonous. Exposure occurs once the pesticide is removed from the container. The toxicity of the pesticide and exposure to the user create a hazard. Both can be reduced, toxicity by dilution and exposure by protective clothing. You can reduce the hazards of spraying and thus the risk of poisoning. Wearing protective clothing reduces the risk. .

Risk of Each Stage	
Handling and mixing concentrate	very high risk
Rinsing empty containers	high risk
Applying outdoors	low to high risk
Applying indoors	medium to very high risk
Cleaning up, rinsing equipment	medium to high risk
Entering treated area within 48 hours	low to medium risk

Never apply pesticides without suitable protection.

Reducing Exposure

- Exposure can be through skin, eyes, mouth, or nose.

- About 80%–85% of the exposure in most spray operations occurs during mixing and loading concentrate.

- Field application usually accounts for 15%–20% of the total pesticide exposure.

- Skin exposure is usually 90%–100% of the total exposure. Around 70% of this is by way of the hands and forearms and 30% involves the rest of the body.

- Inhalation (nose and mouth) exposure is normally 0.1%, but rises to 5%–10% with mist blowers and air blast sprayers.

Protective Clothing

- To reduce skin (dermal) exposure, wear impervious gloves. Always refer to the product label. Unless the label says otherwise, use neoprene or nitrile gloves.

- Always wear waterproof boots, along with coveralls, apron or spray suit, and waterproof cap.

- Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. It's easier for the pesticides to penetrate polyester than cotton. Disposable coveralls are polyethylene and may be laundered several times. Spray suits should be used in highly hazardous conditions such as with mist blowers and air blast machines.

- Protect your eyes with safety goggles when working with any pesticide concentrate.

Respirators

- Use respirators when handling pesticides with labels that call for respiratory protection and carry the warning stop sign with skull and crossbones.

- Use respirators when spraying any pesticide rated as high toxicity or when applying any liquefied gas.

- Respirators are available as air purifiers or self-contained units and come in a wide range of shapes and sizes. Consult the label and your nearest safety supply company for advice. Make sure the cartridge or canister you use has a safety-approved sticker with the letters *NIOSH* (National Institute for Occupational Safety and Health) on it.

Washing Protective Clothing and Equipment

- To keep your protective clothing and equipment functional, clean it thoroughly.

- Never let children or pets come in contact with contaminated clothing or equipment.

- Launder clothing promptly. Wash and store other personal protection items.

- Rinse spray equipment and store it away to prevent children playing with it.

- If fabric clothing is saturated with the concentrate of a highly toxic pesticide, throw it out. Wear nitrile or neoprene gloves when handling severely contaminated clothing. Remove the clothing carefully and immediately put it in a plastic bag and dispose of it in a safe manner.

For a normal spray operation, follow these guidelines, preferably twice a day, but at least at the end of the work day.

- Rinse clothing outdoors.

- Soak and wash clothing separately.

- Soak clothes, with detergent, in a container such as a large bucket or tub; or use the pre-wash cycle of an automatic washer, with detergent. Pre-wash, solvent-based products work on EC formulations.

- Wash only a few garments at a time.

- Use heavy-duty liquid detergents.

- Use hot water, the highest water level, and a hot super–wash cycle.

- Do two complete wash cycles, each with a double rinse.

- After washing, run another wash cycle with detergent and no clothing to decontaminate the washing machine.

- Hang the clothes to dry, outside if possible, to avoid a potential buildup of pesticide residue in the dryer.

Rubber, Vinyl, or Plastic Boots and Gloves

- To avoid getting pesticide on your hands, wash the outside of your boots and gloves with detergent and water before taking them off.

- After removing boots and gloves, wash them inside and out with detergent and water, rinse them thoroughly, and dry them in a well-ventilated area.

Chemical-Resistant Clothing, Goggles, and Face Masks

- Wash plastic or rubber clothing and equipment with detergent and water.
- Rinse thoroughly and dry in a well-ventilated area.

Respirators

- Make a note of the date the cartridge is first used. Discard all cartridges, canisters, and filter pads when breathing becomes difficult, when you notice a pesticide odour, or at the interval set by the manufacturer.
- Never use alcohol or other solvents for cleaning, as they will damage the rubber and plastic.
- Wash the face piece in detergent and water, rinse it thoroughly, and dry it in a well-ventilated area.
- Remove cartridges and filter pads from the face piece and store them in clean, sealed plastic bags.
- Consult Table 1-1 for list of safety supply houses where you can purchase your protective clothing.

Protection for Grain Storage and Enclosed Areas

Canister Gas Masks

Canister gas masks are effective for protection against certain harmful gases, vapours, and particulate matter. They are generally suitable for ventilated areas not subject to rapid change, but should never be used in confined spaces where oxygen deficiency and high gas concentrations may occur.

Self-Contained Breathing Apparatus

Air purifying apparatuses do not work in confined spaces where gas concentrations are unusually high. The lack of oxygen can prove fatal. Under these conditions, you need an air supply provided by a self-contained breathing apparatus (e.g., *Scott Air Pack*).

Using substances that produce ***hydrogen cyanide, methyl bromide, chloropicrin***, or ***phosphine*** can produce high gas concentrations and oxygen deficiency, as can smoke generators, foggers using highly toxic pesticides, and some volatile sprays.

Other Protective Clothing

Wear other protective clothing in keeping with requirements listed on the pesticide's label.

Working Conditions

Use canister gas masks when the surrounding air contains low concentrations of toxic gases, vapours, or particulate matter derived from soil-drench, granular, dust, or foliar spray applications. Pesticides applied in this manner usually have moderate to low toxicity.

You must use a self-contained breathing apparatus (e.g., *Scott Air Pack*) when applying highly toxic pesticides. These can produce high concentrations of toxic gases, vapours, or particulate matter, and a lack of oxygen, especially in an enclosed space (e.g., fumigating grain). Contact your safety supply company for their recommendation.

Space Fumigants and Insecticide Smokes

- When using fumigants or insecticide smoke generators, wear protective clothing to prevent skin and inhalation exposure.
- During and after treatment, lock the building and post warning signs.
- Follow instructions on the product label regarding aeration of treated buildings, warehouses, grain storage bins, or areas before letting anyone enter.

Using Fumigants

- An agriculturalist using methyl bromide plus chloropicrin or aluminum phosphide to fumigate greenhouses, vaults, warehouses, and grain storage must obtain a permit issued under the *Pesticides Act*. To apply for a permit, contact the local pesticide officer with the Ministry of Environment and Energy. You must obtain a permit every time you use these treatments.
- Remove livestock and poultry that are in the same building, especially if they are under the grain bin.
- As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation.
- Always consult the product label.
- When handling ***methyl bromide***, do not wear gloves because these will trap gas next to the skin. You must

TABLE 1–1. Safety Supply Companies in Ontario Providing Protective Clothing or Respiratory Devices

Optical	AEARO Canada 7115 Tomkin Road Mississauga, L5S 1X7	905-795-0700 888-387-9681	*Branches:* Mississauga, Gravenhurst
H.S. Cover Survivair	Levitt-Safety Ltd., 2872 Bristol Circle Oakville, L6H 5T5	905-829-3299 888-453-8488	*Branches:* Kitchener, London, Oakville, Ottawa, Sarnia, Stoney Creek, Sudbury, Thunder Bay
Kasco Helmets	The St. George Co., P.O. Box 430, 20 Consolidated Drive Paris, N3L 3T5	519-442-2046 800-461-4299	www.thestgeorgeco.com
Mine Safety Appliances	MSA Canada Inc., 148 Norfinch Drive, North York, M3N 1X8,	416-667-9400 800-267-0672	
3M Canada Inc. Occupational and Environmental Safety Division	A wide range of distributors–contact P. O. Box 5757, London, N6A 4T1	519-451-2500	
North Safety Products Ltd.	26 Dansk Court, Toronto, M9W 5V8	416-675-2810 800-268-6925	
Racal Airstream, Scott, Willson	Acklands-Grainger Inc. 90 West Beaver Creek Road, Richmond Hill, L4B 1E7	800-387-5744	*Branches:* Hamilton, Kingston, Kitchener, London, St. Catharines, Sarnia, South Porcupine, Thunder Bay, Windsor
Medical Safety First Aid	Kit Care Corp., 91 Kelfield St., Unit 6, Rexdale, M9W 5A4	416-243-3030	*Branches:* Kitchener, London, Orillia, Ottawa, St. Catharines, Stoney Creek

Many of these companies also have dealer outlets. For details contact the supply company

wear a full–face respirator with organic vapour canister or a positive–pressure breathing apparatus.

- When handling *aluminum phosphide*, use cotton gloves and wear a full-face mask respirator with an acid gas canister.
- For more information, obtain the publications *Methyl Bromide Structure Fumigation Procedures* and *Aluminum Phosphide Structure Fumigation Procedures* from the *Ministry of Environment and Energy*.

You must be licensed and obtain a permit before using certain fumigants.

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Storing Pesticides

- The Ontario *Pesticides Act* and *Regulation 914* require that all pesticides be kept out of the reach of children, irresponsible persons, pets, and livestock. They should be stored in a locked facility away from food and feed.
- Herbicides should be stored separately from other pesticides to avoid contamination.
- Always store pesticides in their original containers and keep them tightly closed.
- Never put pesticides in unmarked containers.
- In areas where flooding has been frequent, you must store fertilizers and pesticides above the known high water mark. Contamination of water by these chemicals has led to serious health problems for humans and domestic animals as well as fish and wildlife.
- Also see the OMAFRA Factsheet *Pesticide Handling Facilities*, Order No. 94-037.

Schedule 1, 2 and 5 Pesticides

- Schedule 1, 2 and 5 pesticides must be stored in a facility that is ventilated to the outside.
- A sign that says "CHEMICAL STORAGE WARNING–AUTHORIZED PERSONNEL ONLY" in block capitals must be fixed to the outside of each entrance.
- Only the certified agriculturalist or someone under that person's supervision can may enter the storage facility.

Disposal of Containers and Contaminated Materials

- All paper or cardboard pesticide containers, paper packaging material, or other paper material used to clean up spills should be buried or burned. Make sure that people and animals are kept away from the smoke and that the smoke is not directed toward buildings, highways, roads, or outdoor public areas. Plastic material must not be burned.

- Unrinsed containers can contain as much as three per cent of the original formulation. If this amount of toxic pesticide is discarded with the container, it could be dangerous to other people handling it or to the environment (for example, your water supply). Failure to rinse is also wasteful. Use that 3% for the reason you bought it — to control the pest!

- Rinse all metal, plastic, or glass containers three times with water and add the washings to the spray tank. Alternatively, use a rinsing device. These rinsers can be used to puncture the bottom of a metal or plastic container and rinse the residue directly into the spray tank. This procedure takes less than a minute. Return the rinsed containers for recycling to any dealer cooperating in the pesticide container collection and recycling program.

- Dispose of any unwanted or contaminated pesticide materials through ***Laidlaw Environmental Management (Telephone: 519-451-6630),*** or contact the appropriate registrant to develop an alternative method acceptable to the Director under the *Pesticides Act* (416-323-5095).

Rinse containers properly and apply the rinse water to your plants.

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Sprayers

- Herbicide sprayers that can deliver enough litres per hectare for adequate coverage are satisfactory for applying emulsion-type insecticides. However, if *2,4- D* or related herbicides have been used in them, the sprayers must be cleaned thoroughly or foliage may be damaged. The detergent used should contain ammonia.

- For applying wettable powder formulations, use a high-capacity (450 L/ha), high-pressure, piston pump sprayer with an agitator. Keep in mind that the higher the pressure, the greater the danger of drift to other crops.

- Calibrate your sprayer at least twice during the growing season. Worn nozzles and other parts will alter the amount of spray delivered. For information on calibration, see *Chapter 5, Controlling Weeds*, and *OMAFRA Publication 75, Guide to Weed Control.*

Band Spraying of Insecticides

- When banding insecticides, apply the recommended rate over the strip of row you wish to treat. While banding does not result in a more concentrated spray mixture, it does allow you to cover more area with the same amount used in a broadcast application. For example, if you are treating only a third of the row width, you will be able to cover 3 times the area compared to a broadcast application.

Application by Airplane or Helicopter

- Aerial applicators must be licensed by the Ontario *Ministry of the Environment and Energy* to apply pesticides. In addition, they need permits from the Ministry of the Environment and Energy to apply *Schedule 1 and 5 pesticides* and *Schedule 2 hormone-type herbicides.* Ministry personnel will inspect the area to ensure the application is done safely.

- It is an offence under the Federal *Pest Control Product Act* to use a control product under unsafe conditions. Precautions must be heeded at all times to prevent drift. Extra precautions should be taken when using insecticides applied by air, especially those known to be toxic to honeybees, such as *Sevin* (carbaryl).

- **Do not apply pesticides** if the wind is blowing. Even on the stillest day, some drift occurs. To keep it to a minimum, apply pesticides in the evening or early morning.

- Be sure that the contract specifies the product to be used and its rate of application.

Pesticide Drift

Pesticide drift can leave residues on adjacent crops, be a hazard to nearby people and livestock, and reduce the amount of material in the target area so that it is ineffective. People applying pesticides should make every effort to minimize or prevent pesticide spray drift by:

- correctly calibrating and maintaining spray equipment
- operating the equipment correctly

- being aware of the toxicity of the pesticide being used
- being aware of the weather conditions

Growers are responsible for any material discharged from their sprayers no matter where it is found. This includes liability for adverse affects such as damage to crops or ornamental plants and illegal or unacceptable residue on neighbours' crops or property. You could also be responsible for injury resulting from car accidents caused by windows smeared by spray drift, or for allergic or asthmatic reactions of bystanders even if they are not on your property. Take all precautions necessary to prevent drift off site that might implicate you in any damaging action.

For more information consult OMAFRA Factsheet *Reducing Pesticide Drift and Crop Damage*, Order No. 88-118.

Residues on Crops to be Harvested, Fed, or Grazed

Some pesticide residues disappear quickly; others persist in poisonous form. When crops with persistent residues are fed to livestock, the poisons tend to accumulate in the body fat. Milking cows will excrete them or their metabolic products in the milk. Young calves, heifers, and dry cows will store them in body fat and secrete them when they freshen months later.

To avoid exceeding the residue tolerance for insecticides, herbicides and fungicides:

- Do not use crop residues treated with *Thiodan* or *Endosulfan* for bedding.
- Do not apply chemicals later than recommended.
- Apply only those chemicals registered for the crop and pest.
- Do not apply more than the recommended amount.
- Do not apply them more often than recommended on the label.

For example:

> When controlling insects, do not apply any insecticide later than the recommended number of days before harvest. *Malathion 500 EC 2 - 2.75 L 7* indicates that the malathion spray should not be used later than 7 days before the beginning of harvest and that no more than 2.75 L of an emulsifiable concentrate formulation containing 50% malathion should be used for 1 hectare of crop in an application.

Bee Poisoning

Honeybees, as well as other bees and insects, are important pollinators of several field crops including alfalfa, canola, clover, and trefoil. These pollinators are critical to maximizing seed production. Some crops, such as canola and legumes, are important sources of honey. These crops, and also corn, are important pollen sources. It is therefore important to guard against poisoning bees foraging on these crops.

Insecticides are required for insect control. With careful management, you can get good insect control without killing bees. Listed below are a few points to prevent bee poisoning.

- Do not spray any flowering crop on which bees are foraging. If you must apply insecticides, spray in the early morning or in the evening when bees are not foraging. Bees usually do not forage at temperatures below 13°C.
- If you must apply an insecticide poisonous to bees when they are foraging, notify neighbouring beekeepers so they can protect their bees.
- Do not apply insecticide on windy days to prevent drift toward any nearby hives.
- Remember that ground applications are generally less hazardous than aircraft applications and there is usually less drift.
- When there is a choice, choose the formulation less hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.
- Most *organophosphate* and *carbamate* insecticides are highly toxic to bees.

Notify beekeepers in your area before using any pesticide that may be toxic to bees.

These insecticides used in field crop production are toxic to bees:

TABLE 1–2. Relative Toxicity of Insecticides to Honeybees

Group 1: Very toxic — do not apply to flowering crops or weeds

Trade Name	Common Name
Ambush	permethrin
Basudin	diazinon
Cygon, Lagon	dimethoate
Guthhion	azinphosmethyl
Imidan	phosmet
Lannate	methomyl
Lorsban	chlorpyrifos
Malathion	malathion
Ripcord, Cymbush	cypermethrin
Sevin	carbaryl
Sniper	azinphos-methyl

Group 2: Apply only during late evenings or early morning*

Trade Name	Common Name
Decis	deltamethrin
Dylox	triclorfon
Endosulfan,Thiodan	endosulfan

* Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Relatively Non-Toxic to Bees

All fungicides and insecticides listed in this publication *but not listed in the chart above* can be applied at any time with reasonable safety to bees. However, when planning to apply any pesticide, advise local beekeepers so they can move colonies out of the danger area. Your local agricultural representative has a list of the beekeepers in your area.

New Packaging Method Available

To simplify disposal of empty pesticide packages, the industry has reintroduced a soluble package that dissolves in the tank of the farm sprayer. Water-soluble packaging under the names of *Clean Pak*, *Solupak*, and *Toss–N–Go* is being used for dry flowable and wettable powder formulations of pesticides listed in this publication.

In the majority of cases, the water-soluble packaging material is *PVA* (polyvinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

Handling

- Do not allow water-soluble pouches to become wet prior to adding them to the sprayer tank.
- Do not handle the pouches with wet hands or wet gloves.
- Do not remove water-soluble pouches from the overwrap (outer package) except when adding them to the sprayer tank.
- Always reseal the outer package to protect the remaining pouches from moisture.

Mixing

- After spray tank is one-quarter full of water and the agitator is running, add the water-soluble pouches to the tank.
- Depending on the water temperature and the degree of agitation, these pouches dissolve completely within five minutes.
- As the tank continues to fill, add any other compatible pesticides.

Compatibility

- Do not add a pesticide that is incompatible with the PVA packaging material. The PVA material is not soluble with summer-type oils (e.g., *superior oil*).
- Do not combine with the pouches any material containing boron (e.g., *Solubor*), chelated micronutrients, or water-soluble fertilizers. The chemical combination may cause a sticky, insoluble substance to form in the tank. After applying boron, chelated micronutrients, or water-soluble fertilizers, completely empty and rinse the spray tank before using any product packaged in PVA.
- Read all labels and instructions carefully. For more details contact your farm chemical dealer.

Pesticide Concentrations

Brands of a pesticide from different companies often have different concentrations of the same chemical. If you use one with a concentration different from that listed in this publication, you will need to adjust the rate of application so that you will be applying the same amount of actual chemical (active ingredient).

Seed Treatments

Seed dressings or treatments are poisonous to people and livestock. Do not inhale the fumes or dust when treating or handling treated seed. Wear neoprene or nitrile gloves. Wash all residue of these chemicals from your skin after finishing the treatment. Chemically treated seed is poisonous. Never feed surplus seed to livestock. Destroy all the bags that have held treated seed as recommended in *Preventing Water Supply Contamination* and *Disposal of Containers and Contaminated Materials* earlier in this chapter.

2. Managing Soil Fertility

Fertilizers, used correctly, produce high crop yields at a minimal cost. Always apply fertilizers at a rate consistent with soil fertility as measured via OMAFRA–accredited testing (see below). Low fertility soils may need nitrogen, phosphorus, potassium, and micronutrients at least equal to what the crop removes. However, high fertility or heavily manured soils may not benefit from added fertilizer due to increased costs and possibly reduced yields.

The OMAFRA-Accredited Soil Testing Program

The *OMAFRA Accredited Soil Testing Program* enables you to determine the optimum fertilizer and lime application for crop production. Use this program along with plant analysis and observation of plant nutrient–deficiency symptoms to determine your fertilizer requirements for a specific crop on a specific field.

The OMAFRA Accredited Soil Testing Program recommends the phosphate, potash, and magnesium fertilizers, and the type and amount of lime, appropriate for your soil. The OMAFRA–recommended application rates provided in this publication should produce the highest possible economic yields when accompanied by good management practices. Research shows that higher application rates will sometimes produce higher yields, but the increase is likely to be small and unprofitable.

Soil Tests from Unaccredited Laboratories

Be sure to use an accredited testing service. To be accredited, a laboratory must use OMAFRA–approved testing procedures, demonstrate acceptable analytical accuracy and precision, and provide the OMAFRA fertilizer recommendations.

Some farmers ask OMAFRA staff to interpret results from unaccredited laboratories. If the laboratory correctly uses tests identical to those used by OMAFRA–accredited laboratories, and expresses their test results in the same units, the OMAFRA fertilizer requirements for *phosphate* and *potash* can then be determined.

Unaccredited Soil Tests

Soil tests such as exchange capacity, aluminum, and copper are not accredited by OMAFRA because these tests do not contribute to better fertilizer recommendations. For example, research shows that, on Ontario soils, using exchange capacity to adjust potash recommendations can reduce the reliability of the recommendations.

See Table 2-1, page 12, for a list of laboratories accredited to perform soil tests on Ontario soils and to analyze plant and greenhouse media samples. Please note that these labs may also offer water testing services, but these tests are not accredited by OMAFRA to date.

Field Soil Culture

When to Sample Field Soil

Always allow enough lead time for a soil analysis. Take soil samples the previous fall from fields to be fertilized in the spring. You may, for convenience, sample earlier in the season. If you sample for the next year during the previous summer, you can avoid the rush of harvest and the likelihood of bad weather in late fall.

How to Sample Field Soil

It's important to sample your soil correctly.

- Use a *sampling tube* or a *shovel* to sample soils.
- Sample each field, or uniform section of a field, separately.
- Take at least 20 soil cores from 15 cm deep from any field or area up to 5 ha in size. Take proportionately more cores from fields larger than 5 ha. One sample should not represent more than 10 ha. The more cores you take, the more likely your soil sample will reliably measure the field's fertility.
- Traverse each sampling area in a zigzag pattern to distribute the sampling sites uniformly.
- Sample separately all parts of a field where soil or crops look different or were previously fertilized,

TABLE 2–1. OMAFRA-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories

A & L Canada Laboratories East	Soil, Leaf	2136 Jetstream Road London, ON N5V 3P5	Tel: (519) 457-2575 Fax: (519) 457-2664 www.al-labs-can.com aginfo@al-labs-can.com	Ian McLachlin Greg Patterson
Accutest Laboratories	Soil, Leaf	146 Colonnade Road Unit #8 Nepean, ON K2E 7Y1	Tel: (613) 727-5692 Fax: (613) 727-5222 www.accutestlabs.com phaulena@accutestlabs.com	Peter Haulena Rob Walker Lorna Wilson
Agri-Food Laboratories	Soil, Leaf, Greenhouse media	503 Imperial Road Unit #1 Guelph, ON N1H 6T9	Tel: (519) 837-1600 or 1-800-265-7175 Fax: 519-837-1242 www.agtest.com lab@agtest.com	Dale Cowan Nora Howlett
Soil and Nutrient Lab, University of Guelph	Soil, Leaf	P.O. Box 3650 95 Stone Road West Guelph, ON N1H 8J7	Tel: (519) 767-6306 or (519) 767-6226 Fax: (519) 767-6240 vkerslak@lsd.uoguelph.ca	Virginia Kerslake
Stratford Agri Analysis	Soil, Leaf	1131 Erie Street Box 760 Stratford, ON N5A 6W1	Tel: (519) 273-4411 or 1-800-323-9089 Fax: (519) 273-4411 saa@dacolabs.com	Jim Brimner Keith Lemp Dale Peters Gary Roberts

manured, or limed differently—even if these areas are too small to fertilize separately in the future.

- Do not sample recent fertilizer bands, dead furrows, areas adjacent to gravel roads, or areas where lime, manure, compost, or crop residues have been piled.
- Collect the soil in a clean pail.
- Break up the lumps and mix the soil thoroughly.
- Forward the soil in a *soil sample box* for testing.
- Sample each field once every 2 or 3 years.
- Be sure to enclose a *field information sheet* with every soil sample.

Field Soil Management Practices

Good soil management practices play a major role in ensuring a profitable crop yield. Information about the field, the crop to be fertilized, manure application, and legume sod plowed down is essential for a reliable fertilizer recommendation. Record it on the *field information sheet* that must accompany each soil sample sent for analysis.

Field Soil Micronutrient Testing

OMAFRA offers accredited tests for *manganese* and *zinc*. Use these tests in conjunction with visual deficiency symptoms and plant analysis. OMAFRA–accredited tests are not available for boron, copper, iron, or molybdenum.

- Manganese availability decreases with increasing soil pH. Do not add more lime to your soil than is needed to correct acidity.
- Control zinc deficiency by preventing soil erosion and using animal manures. If necessary, prompt use of zinc fertilizers and foliar sprays can reverse zinc deficiencies after symptoms appear.
- If a zinc soil test value exceeds 200, suspect zinc contamination of the sample or field.

How to Sample Field Soil Micronutrients

It's important to sample your soil correctly. See How to Sample Field Soil, page 11, for soil sampling instructions.

- Micronutrient deficiencies often occur in small patches. In these cases, soil and plant samples taken from the entire field may not reveal the problem. It's best to sample every problem area separately.
- Micronutrients, especially zinc, easily contaminate soil samples. Take great care to prevent any sample contamination. Never use galvanized (zinc plated) sampling tubes to take soil samples for micronutrient tests. A soil sample that contacts a galvanized surface cannot be used for testing.

- Do not collect and mix samples in metal containers. Use clean plastic containers in good condition.
- Be sure that no environmental dust or dirt (e.g., from around buildings) contaminates your samples.

Foliar Analysis (Plant Tissue Testing)

Foliar analysis is the best way to diagnose micronutrient problems. It measures the nutrient content of plant tissue. OMAFRA uses foliar analysis to diagnose suspected nutrient disorders in field–grown and container–grown nursery stock.

When to Sample Plant Tissues

Nutrient levels vary widely with plant age. It's best to take plant tissue samples in July or August. At other times, sample plant tissues if visual symptoms appear.

How to Sample Plant Tissues

It's important to sample plant tissues correctly.

- From deciduous trees and broadleaf evergreen shrubs, select approximately 50 fully expanded leaves midway along a shoot of the current season.
- From conifers, select 15–20 (10 cm) shoots of current season growth. Remove the needles and discard the twigs of pines, spruces, and firs.
- Rinse dirty foliage in distilled water.
- Deliver fresh plant materials directly to the laboratory. If not delivered immediately, always air–dry the tissue samples and ship them in paper bags to avoid spoilage.
- Submit a sample of healthy leaves from the same area to allow comparisons.

See Table 2-1, *OMAFRA–Accredited Soil, Leaf, and Greenhouse Media Testing Laboratories*, for a list of labs and the tests provided by each one.

Soil pH Testing

pH measures soil acidity or alkalinity on a scale from 0 to 14. The midpoint of the scale, 7, is neutral. Values below 7 are increasingly more acid, while values above 7 are increasingly more alkaline. In general, we use *lime* to raise pH (making the soil more alkaline) and *sulphur* to lower pH (making the soil more acid). Soil pH testing helps you determine any necessary pH adjustments.

Issues Surrounding pH

- Iron and manganese solubility increases with increasing acidity. Many other elements become less available as soil pH drops below 6.0.
- Most nursery stock grows well between pH 5.0 and pH 7.2.
- Plants such as red maple, pine, oak, tuliptree, and euonymus may exhibit iron and/or manganese chlorosis if the pH is above 7.0.
- For ericaceous plants and conifer seed beds, the pH should be below 6.5.

Table 2-2 specifies normal foliar nutrient concentrations for nursery stock. Established landscape stock nutrient concentrations may be somewhat lower.

TABLE 2–2. Average Foliar Nutrient Content of Healthy Nursery Stock

Nutrient	N%	P%	K%	Ca%	Mg%	Mn ppm	Cu ppm	Zn ppm	B ppm	Fe ppm
Field Grown										
Conifers	1.7	0.24	1.0	1.0	0.2	88	6	31	35	87
Broadleaf Evergreens	2.3	0.27	1.1	2.5	0.3	25	5	27	42	120
Deciduous Trees and Shrubs	2.8	0.25	1.7	2.4	0.4	62	7	25	58	133
Container Grown										
Conifers & Broadleaf Evergreens	2.5	0.4	1.4	2.0	0.3	52	5	24	48	127

- Long-term use of fertilizers such as ammonium sulphate, ammonium nitrate, urea, potassium sulphate, and mono-ammonium phosphate will gradually reduce soil pH. This is most likely with light, sandy soils and can be corrected by liming the soil.

- Anhydrous ammonia causes a marked, though temporary, soil pH increase when first applied.

- Superphosphate and muriate of potash have little or no effect on soil pH.

Buffer pH Testing

pH adjustments depend on the clay and organic matter content of each soil. Different soils with identical pH values will require different amounts of lime or sulphur to reach a desired pH level. Where soil is too acid, an additional soil test, the *buffer pH*, determines the amount of lime required to increase pH appropriately.

Limestone Type

You can apply *calcitic limestone* or *dolomitic limestone* to your soil. Calcitic limestone is mainly calcium carbonate, while dolomitic limestone is a mixture of calcium and magnesium carbonates.

- When the magnesium in your soil is 100 ppm or less, use dolomitic limestone. It is an excellent, inexpensive magnesium source for acid soils.

- When the magnesium in your soil exceeds 100 ppm, use either calcitic or dolomitic limestone.

Limestone Quality

Two main factors affect the ability of limestone to reduce soil acidity:

- Its *neutralizing value*
  This is the amount of acid a given quantity of limestone neutralizes when it totally dissolves. We express neutralizing value as a percentage of the neutralizing value of pure calcium carbonate. A limestone that neutralizes 90% as much acid as pure calcium carbonate has a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the less you need apply.

- Its *particle size*
  The more finely ground the limestone, the greater its acid neutralizing ability. This value is expressed as the limestone's *fineness rating*. Limestone rock has much less surface area than finely powdered limestone. It neutralizes soil acidity much more slowly.

Agricultural Index

OMAFRA uses the *agricultural index* to compare the acid neutralizing effectiveness of different limestone samples. Lime with a high agricultural index rating is worth more than lime with a lower rating because you apply less of it to achieve the same result. For example:

If two ground limestones, A and B, have agricultural indices of 50 and 80 respectively, the application rate of A is 80/50 times the application rate required for B. Limestone A spread on your farm is worth 50/80 times the price of limestone B per tonne.

OMAFRA soil test recommendations assume an agricultural index of 75. If you know the limestone's agricultural index, you can calculate the correct application rate for limestone of that quality.

Calculating Limestone Application Rates

$$\text{Application rate} = \frac{75}{\text{Agricultural Index}} \times \text{(application rate from soil test)}$$

Raising Soil pH

Use lime to raise pH when it is indicated by soil testing. General lime application rates for most crops, based on soil pH and buffer pH, appear in the table below.

Use Table 2-3 to determine how much lime you need to obtain the correct soil pH value for your crops.

TABLE 2–3. Lime Requirements to Correct Soil Acidity Using Buffer pH

Limestone needed (tonnes/hectare) based on an *agricultural index* of 75

	Target Soil pH = 6.5	Target Soil pH = 6.0
Buffer pH	**Lime if soil pH falls below 6.1**	**Lime if soil pH falls below 5.6**
7.0	2	0
6.5	3	2
6.0	9	6
5.5	17	12
5.0	20	20

Tillage Depth

These lime recommendations should increase soil pH to the target value in the top 15 cm of the soil. If you plow to a greater or lesser depth, you will need proportionately more or less lime to reach a given target pH.

Lowering Soil pH

Sulphur is the first choice for lowering pH provided the starting soil pH value is 7 or less. Other acidifying materials (e.g., aluminum sulfate, iron sulfate) are less effective than sulphur and potentially toxic to plants.

- Lowering the pH of alkaline soils (pH > 7) is not practical. In this situation, replace the soil in small areas of a field. In large fields, consider growing crops that do not require acid soil.

- Cost considerations make it impractical to acidify large fields. You can lower the soil pH in small areas by replacing the soil or amending it with large quantities of acid peat or another acidic organic material. Be sure to test the pH of any organic amendment before using it—leaf mould, compost, and peat may prove to be alkaline rather than the acidic material you want.

- You must apply sulphur *at least* every other year to keep the soil pH near the desired level. Test the soil pH in the spring. If necessary, apply sulphur at the recommended rate.

Table 2-4 shows the amount of sulphur that will bring your soil to the correct pH value for your crops.

TABLE 2–4. Soil Acidification to pH 5.0 Using Sulphur

	Soil Type	
Initial pH	**Sand**	**Loam**
7.0	7.4	22.6
6.5	6.0	17.5
6.0	4.0	12.0
5.5	2.0	6.0

Kg elemental sulphur/100 m² for two successive years

Soluble Salts in Soil

High soil concentrations of water soluble salts interfere with plant water uptake. This can delay or prevent seed germination, kill newly transplanted plants, and seriously retard the growth of either new or established plants.

- Ontario soils are naturally low in soluble salts. These salts rarely cause a crop production problem and are not routinely measured in soil tests. However, excessive fertilizer application, road salt runoff, and chemical spills can cause soluble salts to build up in your soil. This problem is most severe when soil moisture is low and salt concentration high.

- If you suspect salt problems in your soil, send a sample to an OMAFRA–accredited laboratory for analysis. You must specifically request a salt concentration reading. See *How to Sample Field Soil,* page 11, for soil sampling instructions.

- OMAFRA–accredited soil testing laboratories test for soluble salts by measuring the electrical conductivity of a soil/water slurry. The higher the concentration of water soluble salts, the greater the soil's conductivity. If testing indicates a salt problem, correct it by leaching the soil with water.

Table 2-5 interprets soil conductivity readings in Ontario field soils using a 2:1 water:soil paste mixture.

TABLE 2–5. Soil Conductivity Readings

Salt Conductivity Reading (milliSiemens/cm)	**Rating**	**Plant Response**
0-0.25	Low	Suitable for most plants when using recommended amounts of fertilizer
0.26-0.45	Medium	Suitable for most plants when using recommended amounts of fertilizer
0.46-0.70	High	May reduce emergence and cause slight–severe damage to salt sensitive plants
0.71-1.00	Excessive	May prevent emergence and cause slight–severe damage to most plants
1.00	Excessive	Expected to severely damage most plants

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Organic Amendments to Soil

Organic matter helps maintain soil structure, aeration, and water penetration. Soil structure and aeration promote root development and plant growth while rapid water penetration minimizes erosion. When organic matter breaks down and/or is lost through clean cultivation practices, replace it by adding organic amendments to the soil.

Applying Manure

Manure supplies organic matter and many of the nutrients needed for crop production. It is most effective when applied to crops requiring nitrogen on soils that need phosphorus and potassium.

- Store manure in a way that saves the liquid portion and minimizes exposure to air.
- Do not spread manure in winter or early spring on fields subject to runoff
- For best results, apply manure in the spring. Cover it with soil the same day to prevent nitrogen loss—your crop loses about 25% of the applied nitrogen if you don't cover the manure immediately. Most nitrogen loss to the air occurs in the week after application.
- Many fields require supplemental nitrogen beyond what manure provides. When you apply manure in the fall or winter, you lose considerable nitrogen through leaching. OMAFRA nitrogen adjustment tables assume you will apply manure in the spring. In fall or winter, use 50% more supplemental nitrogen than the table recommends.
- The nutrient content of manure varies with a variety of factors such as livestock type, age, and rations. Storage methods and water added also affect manure's nutrient composition.

How to Sample Manure

It's important to sample manure correctly.

- For liquid manure, mix the tank contents thoroughly before taking a sample.
- For solid manure, take forkfuls from many places in the stack — not just from the surface. Mix these samples thoroughly. Then submit 1–2 kg for laboratory testing.

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Fertilizing

Fertilizing Field Nursery Stock

You must fertilize nursery stock regularly to achieve optimum growth and maximum profit. Dry and liquid fertilizers produce similar results, so choose a suitable fertilizer formulation on the basis of soil test results, consistent supply, handling equipment available, application cost, and cost/kg of elemental nitrogen.

OMAFRA provides reliable soil test results for phosphorus and potassium. However, field soil nitrogen levels fluctuate rapidly, making nitrogen soil tests unreliable.

Table 2-6 below offers guidance on manure application rates and resulting fertilizer reductions. However, each batch of manure is unique-you must analyze it for accurate nutrient information.

TABLE 1–3. Manure Application Rate and Nutrient Adjustment Guidelines

	Nitrogen (kg/ha)			*Phosphate*	*Potash*
Class of Livestock	**Fall/Winter**	**Spring[1]**	**Spring C[1]**	**P_2O_5 (kg/ha)**	**K_2O (kg/ha)**
Liquid manure at 10 cubic metres/hectare (890 gallons/acre)					
Cattle & mixed livestock	5	10	12	4	16
Poultry	23	46	58	22	26
Swine	8	15	19	7	14
Solid manure at 10 tonnes/hectare (4.5 tons/acre)[2]					
Cattle, mixed livestock	12	24	30	10	44
Poultry	70	140	175	75	96
Swine	15	30	38	20	26

[1] *Spring* is spring applied manure not covered immediately; spring C is spring applied manure covered within 1 day or injected

[2] Density of manure in spreader may vary from 400 kg/m^3 (25 lb/ft^3) for heavily bedded or very dry manure to 1000 kg/m^3 (62 lb/ft^3) for semi–solid and liquid manures

Use Table 2-7 below as a guide to the phosphorus requirements of new and established plantings in your soil. *(Approved by Ontario Soil Management Research Committee, Nov. '96)*

TABLE 2–7. Phosphorus Requirements for New and Established Field Nursery Stock

Phosphorus (0.5 N Sodium Bicarbonate)

	Phosphate (P_2O_5) Required (kg/ha)		
Soil Test Value (ppm)	**Rating**	**New Planting**	**Established Planting**
0–3	Low	140	100
4–5	Low	130	90
6–7	Low	120	80
8–9	Low	110	70
10–12	Low	100	70
13–15	Low	90	60
16–20	Medium	70	50
21–25	Medium	60	40
26–30	Medium	50	30
31–40	Medium	40	20
41–50	High	0	0
51–60	Very High	0	0
61–80	Excessive	0	0
80+	Excessive	0	0

Use Table 2-8 below as a guide to the potassium requirements of new and established plantings in your soil. *(Approved by Ontario Soil Management Research Committee, Nov. '96)*

TABLE 2–8. Potassium Requirements for New and Established Field Nursery Stock

Potassium (1 N Ammonium Nitrate)

	Potash (K_2O) Required (kg/ha)	
Soil Test Value (ppm)	**Rating**	**New or Established Planting**
0–15	Low	130
16–30	Low	120
31–45	Low	110
46–60	Low	100
61–80	Low	90
81–100	Low	80
101–120	Medium	70
121–150	Medium	60
151–180	Medium	40
181–210	High	0
211–250	Very High	0
250+	Excessive	0

Fertilizing Seed Beds and Transplant Liner Beds

- Prior to planting in the spring, incorporate about 50 kg of actual nitrogen (e.g., ammonium nitrate) per hectare. You may wish to apply additional nitrogen during trials of particular species under specific growing conditions.
- Add organic matter, such as rotted barnyard manure or compost, prior to planting. Apply it at a rate of about 45 t/ha. Growing green manures on the land provides another good source of organic matter.
- When you add fresh, undecomposed organic matter that is low in nitrogen, you must incorporate nitrogen to compensate for microbial decomposition. For example, use 15 kg of actual nitrogen (e.g., ammonium nitrate) per tonne of fresh sawdust.
- When preparing the seed and liner beds, incorporate phosphorus and potassium as indicated by a soil test.
- In early spring of the second season, apply phosphorus and potassium as indicated by a soil test and apply nitrogen at the rate of 50–75 kg/ha.

Fertilizing Established Field Stock

Fertilize established field stock based on phosphorus and potassium soil test recommendations. Field soil nitrogen levels fluctuate rapidly, making nitrogen tests unreliable.

- Apply fertilizer in the spring, 2–3 weeks before growth resumes.
- Don't apply high rates of nitrogen after mid–July to avoid stimulating succulent growth in the fall. You may choose to apply small amounts of nitrogen regularly throughout the growing season or via a slow–release formulation.
- Fall fertilization is crucial. Research shows that growth the season after fall fertilization significantly exceeds growth after fertilization during the spring of the same season.
  - Apply up to half the year's fertilizer requirement after top growth ceases (mid-September to mid-October). Roots will grow and absorb nutrients whenever soil temperatures remain above 5°C.

- Nitrogen is either used quickly or lost through leaching. Apply nitrogen (e.g., ammonium nitrate) every season using 100–150 kg of actual nitrogen per hectare. You may apply additional nitrogen during trials of particular species under specific growing conditions.

- For optimum fertility, sandy soils need more nitrogen and potassium fertilizers than clay soils. When no soil test is available, apply 100 kg of actual nitrogen per hectare using a 3-1-2 ratio fertilizer.

- Don't apply fertilizer in late fall or winter. It will not be absorbed because of the cold soil temperatures and may be lost through runoff.

Use Table 2-9 to identify the N% of common fertilizer formulations.

TABLE 2–9. Nitrogen Sources

Nitrogen Materials	% Nitrogen (N)	Other Elements Supplied
Ammonium Nitrate	33–34	
Urea	45–46	
Ammonium Sulfate	20	24% Sulphur (S)
Calcium Nitrate	17	37% Calcium (Ca)
Sodium Nitrate	16	
Potassium Nitrate	13	44% Potassium (K)

Use Table 2-10 to identify common sources of phosphorus.

TABLE 2–10. Phosphorus Sources

Phosphorus Materials	P_2O_5%
Superphosphate	20
Triple Superphosphate	44–46
Monoammonium Phosphate	48–52
Diammonium Phosphate (18-46-0)	46

Use Table 2-11 to identify common sources of potassium.

TABLE 2–11. Potassium Sources

Potassium Sources	K_2O%
Potassium Chloride (muriate)	60 to 62
Potassium Sulfate	50
Sulfate of Potash Magnesia	22 (11% Mg)
Potassium Nitrate	44

Fertilizer Application Rates

Use this method to determine the nitrogen application rate of any nitrogen fertilizer formulation: *multiply the result by 100 to specify kg of fertilizer/hectare.*

$$\text{Kg fertilizer per } 100\text{ m}^2 = \frac{100}{\%\text{ N in fertilizer}} \times (0.5\text{ kg N}/100\text{ m}^2)$$

Use Table 2-12 to determine how much fertilizer will supply a given quantity of elemental nitrogen per specified area when you know the percentage of nitrogen in the fertilizer formulation.

TABLE 2–12. Nitrogen Equivalency Table

	Kilograms of Fertilizer Needed to Supply:		
Nitrogen% in the fertilizer	**0.5 kg of actual nitrogen/100 m^2**	**50 kg of actual nitrogen/ha**	**100 kg of actual nitrogen/ha**
5	10	1000	2000
6	8.33	833	1667
7	7.14	714	1429
8	6.25	625	1250
9	5.55	556	1111
10	5.00	500	1000
11	4.55	455	909
12	4.16	417	833
13	3.84	385	769
14	3.57	357	714
15	3.33	333	667
16	3.12	313	625
17	2.94	294	588
18	2.77	278	556
19	2.63	263	526
20	2.50	250	500
21	2.38	238	476
22	2.27	227	455
23	2.17	217	435
24	2.08	208	417
25	2.00	200	400
26	1.92	192	385
27	1.85	185	370
28	1.79	179	357
29	1.72	172	345
30	1.67	167	333
31	1.61	161	323
32	1.56	156	313
33	1.50	152	303
34	1.47	147	294
35	1.43	143	286
46	1.09	109	217

Nursery Container Culture

Using Pots

All current potting machines accept plastic and fibre pots.

- Use high–density plastic pots for long–term container growing.

- Fibre pots are useful for short–term growing and for winter storage or spring shipping. Fibre pots are not recommended for long–term growing because they soften, decompose, and may be damaged by rough handling.

- Pot colour affects mix temperature and root development. Root growth decreases when media temperatures approach 30°C. Studies show that black and dark–green pots may be 10°C hotter than white or light reflective pots, reaching almost 40°C on the inner surface of the sunny side. However, pots with a white or reflective exterior are not widely available. Light–coloured pots along the outside rows of a block and for widely spaced plants are not recommended. Dark colours in the centre of a pot–to–pot block are acceptable, as sunlight will not strike the pot wall. To diagnose high–temperature injury, remove the pot and compare root growth on the sunny and shaded sides of the pot.

- Root circling in circular pots rarely causes problems for typical container–grown landscaping stock in Ontario. If necessary, you can minimize root circling and encourage root branching by using square pots or pots with vertical ribs. Unfortunately, large pots of these types are difficult to find. You can usually reduce root circling in circular pots by repotting stock before the root system becomes pot bound.

Using Potting Mixes

A successful container–growing operation depends on the potting mix.

- Before using a potting mix, ensure it is well composted. Stockpile it for several months and turn it occasionally.

- Mix ingredients need to be free of insects, diseases, and weeds, readily available (to assure a continuous supply) and reasonably priced.

- Make sure the potting mix is heavy enough to support tall plants in the wind.

- The traditional mix has been peat combined in equal measure with concrete–grade sand. However, this mix becomes alkaline when the sand has a high pH and aeration is somewhat low.

- Composted bark helps to suppress root rot disease organisms. It provides good aeration when mixed with peat. Mixes such as 2 parts bark to 1 part peat *or* equal parts bark and peat to 1 part sand provide adequate aeration and water holding capacity.

- Well–decomposed coarse sawdust is a useful mix ingredient. Avoid fresh sawdust due to its very high carbon/nitrogen (C/N) ratio. Generally, the lower the C/N ratio, the faster the material will decompose. The C/N ratio of sawdust is 1,000/1, of conifer bark 300/1, and of hardwood bark 150/1. Therefore, hardwood bark will decompose more quickly than conifer bark. To compensate for a high C/N ratio and enhance decomposition, add 1 kg of actual nitrogen (e.g., ammonium nitrate) per m^3 of bark.

- Adequate aeration is vital. Since roots require oxygen to grow properly, a poorly aerated mix will restrict root growth. Water holding ability is also important, though secondary to aeration.

Using Soilless Media

Soilless media differ greatly (chemically and physically) from field soils.

- Peat and bark–based media have good aeration and moisture–holding properties but limited nutrient–holding capacity. You must manage fertility closely to achieve maximum crop growth potential.

- High pH affects the availability of most micronutrients. Therefore, avoid growing media with pH above 6.5. High pH values from the addition of coarse sand may lead to low levels of iron or manganese.

Determining Potting Mix Porosity

Use this method to test new potting mixes. Compare plants grown in your standard potting mix with plants grown in a new one to select the best media.

- The *total porosity* of a mix is the space between mix particles that air or water can potentially fill. Aim for a total porosity value above 50%.

- The *aeration porosity* of a mix is the per cent of space filled by air after irrigation water has drained out. To determine this vital value, follow the steps outlined below. Aeration porosity should be above 15% and below 30%. Too much aeration (aeration porosity >30%) won't harm your plants, but will require frequent irrigation. A potting mix with a high percentage of very fine particles (i.e., <0.5 mm) results in low aeration porosity and poor drainage.

Use mixes with a high aeration porosity, 20%–25%, for pines and yews. Junipers and white cedar can tolerate lower aeration porosity values.

To determine media porosity, you will need:

- your normal growing pot (#1, #2, etc.)
- a way to cover or plug the pot drain holes
- a graduated cylinder or other liquid measure
- some dry potting mix

To calculate the porosity of your potting mix:

1. Cover or plug the drain holes of the container.
2. Fill the container with water to the normal level of the potting media. Measure the volume of this water and record the number. This amount of water is the ***total container volume*** [A].
3. With the pot empty and the drain holes still plugged, fill the container to the normal level of the potting media with slightly moist media. Be sure that the container is level.
4. Slowly add a known volume of water to the media. Continue adding water until a water slick appears on the surface. The volume of water added is the ***pore volume*** of the media [B]. Record the amount of water you added.
5. Without moving the pot, remove the drain hole covers or plugs. Let the water drain into a bucket, then measure the volume of water that drained. This is the ***aeration pore volume*** [C]. Record this number.
6. Calculate the media porosity:

$$\textbf{Total porosity} = \frac{(B\text{x}100)}{A}$$

$$\textbf{Aeration porosity} = \frac{(C \text{ x } 100)}{A}$$

$$\textbf{Water retention porosity} = \text{total porosity} - \text{aeration porosity}$$

For example, if:

Total container volume **[A] = 5180 ml**

Pore volume (water added to saturate the media) **[B] = 3354 ml**

Aeration pore volume (water drained from container) **[C] = 1080 ml**

then:

$$\textbf{Total porosity} = \frac{(3354) \text{ x } (100)}{5180} = \textbf{65\%}$$

$$\textbf{Aeration porosity} = \frac{(1080) \text{ x } (100)}{5180} = \textbf{21\%}$$

$$\textbf{Water retention porosity} = 65\% - 21\% = \textbf{44\%}$$

Adjusting Potting Mix pH

It's important to maintain the right pH for your container crops.

- Maintain a potting mix pH between 5.5 and 7.0.
- Do not use alkaline sand in the mix when growing pH sensitive crops.
- Acidifying fertilizers may help to control pH. When using injectors, apply fertilizer and acid concentrates as separate solutions.
- You can acidify irrigation water with nitric or phosphoric acid, depending on the bicarbonate content of the water.
- *Juniperus* and *Thuja* will grow adequately at a higher pH, but plants such as *Euonymus, Rhododendron,* and *Taxus* will exhibit iron and/or manganese chlorosis if the pH is above 7.0.

Fertilizing Container Stock

Most container mixes contain little or no soil, with resulting low fertility. You may apply water soluble or controlled–release fertilizers to correct this problem.

Fertilizers affect the environment, especially the ground water. Liquid feeding with water soluble fertilizers was widely accepted in the past. However, given current environmental concerns, growers it is important to strive for maximum efficiency and minimum environmental impact from your fertilizer program. You can do this by minimizing fertilizer leaching and collecting irrigation water runoff.

How to Sample and Test Container Soils

It's important to sample your soil correctly.

- Potting mixes do not retain nutrients due to rapid leaching. This makes soil tests a vital part of container production operations. Sample every 2 weeks. As test results become familiar, pH and salt readings may provide sufficient biweekly information, along with an occasional nutrient analysis.

- To obtain a sample, remove the pot and take a core through the medium midway between top and bottom.

- Sample container-grown stock with a small–diameter sampling probe.

- Take samples from at least 10 pots.

- If you apply water soluble fertilizer continuously, sample the soil a half hour after application.

- When using a dry surface fertilizer (granular or pellet), always sample before adding the fertilizer. Insert the probe carefully, avoiding any surface fertilizer residue.

- When both are applied at recommended rates, water soluble fertilizers normally produce lower salt concentrations than pre–incorporated controlled–release fertilizers.

- Analyze all soil samples from container potting mixes at an OMAFRA–accredited laboratory using a *saturated paste analysis for greenhouse media*.

- Garden centres must continue controlling the fertility of container-grown plants to ensure proper growth—especially with plants grown previously using liquid fertilizers. Add a controlled–release fertilizer according to the manufacturer's recommendation. Do not add fertilizer on the surface before shipping.

Using Water Soluble Fertilizers

Apply water soluble fertilizers through the irrigation system using an accurate concentrate diluter. Under conventional overhead irrigation, water soluble fertilizers leach quickly from container media. Because collection of runoff water is not standard practise, the fertilizer salts can move to underlying soils and groundwater systems. To reduce the amount of leached salts, reduce fertilizer rates and/or reduce the amount of water passing through the media (e.g., pulse or cyclic irrigation).

- In theory, soluble fertilizers are applied at every watering. However, this does not use water and fertilizer efficiently. Actual results indicate little difference in growth from constant vs. intermittent fertilizing.

- When water soluble fertilizers do not contain micronutrients, add these to the mix before potting or as soluble trace elements during the growing season. Dry materials with added bulking agents are less concentrated, making them easier to blend into the mix. Use these as recommended by the manufacturer.

- Commercial water–soluble fertilizers come in numerous analyses (e.g., 20–20–20 or 28–14–14). Use them at the rate of up to 200 ppm nitrogen (i.e., up to l00g of 20–20–20 per 100 litres of water) for constant feeding.

Calculating Parts/Million (ppm) of a Dilute Liquid Feed

$$\text{ppm nutrient} = \frac{(\text{fertilizer weight in kg}) \times (\text{\% nutrient in fertilizer}) \times (1000)}{(\text{volume of stock solution in L}) \times (\text{dilution rate})}$$

Calculating Fertilizer Needed to Obtain a Given Nutrient Level in Dilute Feed

$$\text{Kg fertilizer per litre} = \frac{(\text{ppm diluted feed}) \times (\text{dilution rate})}{(\text{\% nutrient in fertilizer}) \times (1000)}$$

Using Controlled–Release Fertilizers

Controlled–release (encapsulated) fertilizers work well with container stock.

- You can incorporate controlled–release fertilizers into the potting mix or top dress with them later. Use as suggested by the manufacturer.

- Avoid excessive mixing when preparing a potting mix. This may break fertilizer particles, which can cause problems due to excessive salt.

- Do not store potting mixes with pre–incorporated, controlled–release fertilizers for an extended time period.

- Several controlled–release fertilizer formulations now contain micronutrients. When controlled–release fertilizers do not contain micronutrients, add these according to the manufacturer's recommendation.

(Superphosphate is one common manufacturer's recommendation.)

- Research suggests that supplemental fertility, particularly nitrogen, may benefit fast growing crops when using controlled–release fertilizers. Nitrogen soil tests *are* reliable for container soil. Apply nitrogen (e.g., ammonium nitrate) to the plants at the rate of 200 ppm whenever soil tests show unacceptably low nitrogen values (i.e., under 39 ppm).

- Check soil test values in early July of the second growing season after using pre–incorporated controlled–release materials. You may supply necessary nutrients via water soluble fertilizers in the irrigation system or through surface fertilizer applications. Some controlled–release materials provide nutrition for two growing seasons.

- Controlled–release fertilizers may produce inconsistent soil test results if capsules break during sampling, shipping, or testing.

- Research shows that *Juniperus* grows better the first year when you pre–incorporate fertilizer in mixes with low aeration porosity. When a small plant is growing in a 6 L pot, watering to fertilize may cause poor growth due to low aeration.

Measuring Nutrient Levels of Container-Grown Crops

It's important to sample your media correctly. See *How to sample and test container soils*, page 21, for sampling instructions.

- Woody plants use both nitrate and ammonium types of nitrogen. Under most summer conditions, ammonium nitrogen converts quickly to nitrate nitrogen due to microorganism activity.

- Current container soil tests measure nitrate nitrogen. However, ammonium nitrogen can be measured on request.

- Controlled–release fertilizers may produce inconsistent soil test results if capsules break during sampling, shipping, or testing.

- OMAFRA–accredited laboratories report container media nutrients in parts per million (ppm).

Fertilizer Application Rates

For landscape plantings, apply nitrogen at 1.5–2.0 kg per 100 m^2 using a pure nitrogen or high nitrogen complete fertilizer. Water thoroughly after application. Low tree vigour, a long growing season, and/or well drained sandy soil may necessitate higher application rates. [See Table 2-13, *Nutrient Levels for Most Container Crops*, page 23.]

Fertilizing Landscape Plantings

Most soils have enough inherent fertility to grow plants—there is no need to fertilize thriving landscape plants. Fertilize when you need to, based on soil characteristics, type of plant and desired growth.

- Fertilizer helps plants establish after transplanting and improves plant vigour.

- Trees growing in lawn areas benefit from fertilizers applied to the grass — apply herbicide-free turf fertilizer at a rate slightly above the recommended rate for grass.

- Any complete, high nitrogen fertilizer is fine for trees and shrubs. Most studies show that nitrogen improves plant growth more than phosphorus and potassium. Distribute the required amount of fertilizer evenly on the soil surface beginning well beyond (as much as 2 times beyond) the dripline. Extend the fertilizer inward to 2/3 the distance between the dripline and the trunk. If paving obstructs part of the area under the branch spread, reduce the quantity of fertilizer accordingly.

- You may split fertilizer applications during the year, applying up to half the annual rate in the fall. Apply fertilizer in the early spring, 2–3 weeks before growth begins. Fertilize again in the fall after top growth ceases and the danger of growth stimulation has passed (mid-September to mid-October).

- Don't use large amounts of fertilizer with readily available nitrogen between mid-July and early September.

- If you will fertilize only once, use fertilizers with 60% or more of their nitrogen in slow release form, since the nutrients become available slowly with minimum leaching. Pressure injecting slow release fertilizer into the soil is acceptable.

- If the soil needs aeration or when it is important not to overstimulate the vegetation growing on the surface, use the drill hole method of tree fertilization.

TABLE 2–13. Nutrient Levels for Most Container Crops

Nutrient Concentration		What to Do
Nitrogen (as water-soluble nitrate NO_3 N)		
Low	0–39 ppm	Add extra nitrogen to the feeding program, especially if using slow–release materials.
Normal	100–199 ppm	Continue feeding at high levels and check total salts.
Excess	250+ ppm with high salts	Discontinue feeding nitrogen and check total salts as root damage may occur. Higher rates may be needed for optimum growth in a bark mix and to maintain the same soil test level as in a peat mix.
Phosphorus (as water-soluble P)		
Low	0–2 ppm	Add additional phosphorus to the feeding program.
Normal	6–9 ppm	Continue feeding at high levels and check total salts.
Excess	50+ ppm	Discontinue feeding phosphorus.
Potassium (as water-soluble K)		
Low	0–59 ppm	Add additional potassium to the feeding program.
Normal	150–250 ppm	Continue feeding at high levels and check total salts.
Excess	350+ ppm	Discontinue feeding and leach. Plants may tolerate higher levels if the mix contains a high proportion of organic material. (Leaching is ineffective for removing incorporated controlled–release fertilizer.)
Total Salts in mS/cm (mhos x 10^{-3})		
Low	0–0.75 ppm	Check for adequate nitrogen and potassium levels.
Normal	2.0–3.5 ppm	Continue the feeding program.
Excess	3.5+ ppm	Discontinue feeding. Plants may tolerate higher levels if the mix contains a high proportion of organic material.
Calcium (as water-soluble Ca)		
Low	0–79 ppm	Add extra soluble calcium to the feeding program. (Calcium levels are easily raised by adding dolomitic lime or gypsum to the media.)
Normal	200–300 ppm	
Excess	400+ ppm	
Magnesium (as water-soluble Mg)		
Low	0–29 ppm	Apply 0.5 kg/1000–litres of magnesium sulfate through the irrigation water.
Normal	70–200 ppm	
Excess	200+ ppm	
Miscellaneous		
	Sulfate levels should not exceed 300 ppm	
	Chloride levels should not exceed 50 ppm	
	PH should fall between 5.0 and 6.5	

3. Insects and Diseases

Insects, mites, and diseases may attack any type of plant during the growing season. Fortunately, natural factors usually control pest populations and minimize plant damage. When a pest problem does occur, you may need to apply artificial control measures to prevent serious crop injury.

Effective, economical, and safe pest control requires very early detection. This is accomplished by frequently inspecting the plants. In addition, you must be able to:

- identify the pest concerned
- understand its life cycle
- know when and how to deal with it

Insects and Mites Affecting Trees and Shrubs

Insects and mites are broadly classified according to their feeding habits and the associated damage they cause to woody plants.

- Defoliators
- Sucking insects
- Borers
- Gall makers
- Soil pests

Some damage is so characteristic you can identify the insect without seeing the pest at work. Indeed, the unaided eye cannot see some tiny pests, such as mites. Other pests develop within the plant tissues, concealed from view.

Use Table 3-1 to identify insect injuries to nursery and landscape plants from plant damage.

TABLE 3–1. Symptoms and Possible Causes of Insect Injury (by plant injury)

Category	Symptom	Possible Causes
Chewed leaves and/or chewed flowers	➢ Pieces of leaf or flower missing ➢ Entire leaves or flowers missing	Caterpillars (moth larvae, butterfly larvae) Larvae or adult beetles Sawfly larvae Grasshoppers Snails Slugs
Discoloured leaves	➢ Bleached leaves ➢ Bronzed leaves ➢ Silvered leaves ➢ Stippled leaves ➢ Streaked leaves	Lace bugs Plant bugs Spider mites Leafhoppers Aphids Psyllids Thrips
Plant part distortion	➢ Mined leaves ➢ Skeletonized leaves	Beetle larvae Caterpillars Sawflies
	➢ Curled/cupped leaves ➢ Galls on leaves, stems, flowers, twigs ➢ Twisted growing points	Aphids Gall wasps Gall flies Psyllids Eriophyid mites
Plant part die back	➢ Dying leaves, twigs, branches	Twig pruners
	➢ Dying whole plant ➢ Holes and frass observed ➢ Wilting	Root feeding beetle larvae Boring insects Scales Adelgids

Use Table 3-2 to identify insect injuries to nursery and landscape plants from visible insect matter.

TABLE 3–2. Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter)

Symptom	Possible Causes
➤ Dark fecal spots	Aphids Soft scales Leafhoppers Mealy bugs Psyllids Whiteflies
➤ Honeydew ➤ Sooty mold	Lacebugs Greenhouse thrips Some plant bugs Sawfly adults
➤ Silken mats ➤ Spittle ➤ Tents ➤ Webs	Leafrollers Leaftiers Spittlebugs Tent caterpillars Webworms
➤ Cast skins	Aphids Cicadas Clearwing moth larvae Lacebugs Leafhoppers
➤ Pitch mass	Larvae of certain kinds of moths and beetles
➤ Sap flow	Larvae of certain kinds of moths and beetles
➤ Pitch tubes	Bark beetles
➤ Flocculence (cottony waxy material)	Adelgids Aphids Certain scales Mealybugs Psyllids
➤ Slime	Slugs Snails

Defoliators

Defoliating insects eat solid foliage tissue. They may feed singly or in dense colonies and have diverse feeding habits. For example, some defoliators consume entire leaves while others eat only interveinal tissue; some skeletonize the leaf surface while others mine between the leaf surfaces.

Some defoliators are visible on leaves while others hide within a web, folded leaf, or portable shelter. They damage plants by reducing the leaf area of the plant. This interferes with photosynthesis, depriving the plant of food. It also interferes with the transportation and translocation of food within the plant. Some common types of defoliators are listed below; a comprehensive pest and disease table appears on page 39.

Caterpillars

Caterpillars are moth and butterfly larvae. They may feed in colonies or individually. Caterpillars have 3 pairs of true legs on the abdomen, close to the head. About 5 pairs of fleshy "pro-legs" are located further back along the abdomen. (This group also includes loopers or "inch worms." Loopers have 2–three pairs of pro-legs.)

Leaf Eating Beetles

Many beetles feed on leaves both as adults and as larvae. Beetle feeding can completely devour, skeletonize, or mine the leaves.

Leafminers and Casebearers

Leafminer and casebearer larvae develop within leaf tissues or in a protective case of leaf fragments that they carry to their feeding site. While the pests are often concealed, their characteristic tunnels make leafminer infestations easy to identify. The tunnels may be straight, serpentine, or irregular.

Sawflies

Sawflies feed in colonies and quickly strip foliage from their host plants — usually during June and July. The adults have 4 wings and often resemble small, amber-coloured bees. The larvae of most species look similar to caterpillars, with 3 pairs of true legs on the abdomen, close to the head. They usually have 7–eight pairs of "pro-legs," fleshy legs located further back along the abdomen.

Sucking Insects

Sucking insects include aphids, lacebugs, leafhoppers, mealybugs, mites, scales, spittlebugs, and thrips. This group of pests weakens trees and shrubs by sucking the sap. Some also inject secretions that injure or kill plant cells. Most species, though small and inconspicuous; are very troublesome pests.

Because their foliage is not chewed or torn, infested plants may suffer severe injury before symptoms appear. Signs of damage include mottling and fading leaf colour, curling and twisting leaves, wilting foliage and tender shoots, hardening flower buds, and malformed flowers.

Some common types of sucking insects are listed below; a comprehensive pest and disease table appears on page 39-65.

Aphids

Aphids (plant lice) are small, soft bodied, pear–shaped insects that vary from green to shades of red, brown, or black. Some aphids feed on the leaves; others feed on the roots. Aphids commonly cluster on new growth or on the underside of leaves.

Aphids secrete a sweet sticky substance called "honeydew" which attracts ants, flies, and wasps. Honeydew can be a nuisance when it coats objects beneath infested plants. A black sooty mold may grow on the honeydew, making the plants unsightly.

Leafhoppers

Leafhoppers are small, wedge–shaped, active insects that run, hop, or fly when disturbed. Leafhoppers are usually greenish or yellow in colour, though some are striped. They commonly injure woody hosts such as apple, elm, honeylocust, maple, and rose.

Leafhoppers feed on the undersides of leaves, causing stippling or bleaching. Small whitish dots appear on the leaves' upper surface. The cast skins of nymphs often remain attached to the lower surface of a leaf — their presence helps identify the pest.

Mites

Mites are tiny animals related to spiders and ticks — not true insects. Sometimes called "spider mites," they produce webbing between plant needles or leaves. This keeps the mites from becoming dislodged and protects them from their natural enemies.

Mites reproduce rapidly during hot, dry weather and may produce several generations a year. They attack evergreens and deciduous trees, causing speckling, bleaching, or bronzing of foliage. Tiny spherical eggs or broken eggshells appear as specks or spots. In severe mite infestations, foliage may drop prematurely.

Serious mite damage happens quickly, so it's important to identify mite infestations early in the season. Most mites are not visible with the naked eye. To identify a mite infestation, use a 16x-hand lens. Alternatively, hold a sheet of white paper under a branch and tap the branch sharply. Some mites will drop onto the paper — they appear as tiny specks as they crawl about.

Mite species commonly associated with trees are:

- **Clover mite** (*Bryobia praetiosa*) on the honeysuckle and elm
- **European red mite** (*Panonychus ulmi*) on fruit trees
- **Oak red mite** (*Oligonychus bicolor*) on oaks
- **Honeylocust spider mite** (*Eotenranychus multidigituli*) on honeylocust
- **Spruce spider mite** (*Oligonychus ununguis*) on spruce, hemlock, arborvitae, and juniper
- **Two spotted spider mite** (*Tetranychus urticae*) on elm, linden, rose, and ornamental fruit trees
- **Rust mite** on elm, honeylocust, maple, oak and privet

Thrips

Thrips are tiny, slender–bodied insects that affect the leaves and flowers of honeylocusts, privets and pines.

Plant Bugs

This group of insects removes plant sap using piercing, sucking mouthparts. Both adults and nymphs cause damage. They often injure the young, developing shoots and leaves. Symptoms of damage include stippled leaves, deformed leaves, and stunted shoots.

Scales

Scale insects are tiny and inactive for most of their lives. They often blend with the host plant's colour, making them hard to find. For ease of identification, we divide scales into three groups:

- armoured scales
- soft or unarmoured scales
- mealybugs

Armoured scales

Armoured scales are common on trees and shrubs. The scales vary in length or diameter from 2–3 mm and secrete a hard, waxy covering over their bodies. Armoured scales may be circular, oblong, or pear-shaped.

Soft scales

Soft scales are either bare or enclosed in waxy or cottony secretions.

Mealybugs

Mealybugs are soft–bodied insects that are usually covered with a powdery, cottony–wax material. Mealybugs produce honeydew. They range from about 5–8 mm long when full grown and, unlike other scale insects, mealybugs can move about throughout their entire life cycle.

Borers

Borers are beetle and moth larvae that tunnel into the buds, shoots, bark, or wood of trees and shrubs. Some species attack healthy trees, but most attack trees and shrubs already weak from another cause.

It's important to prevent borer injury, as infested plants may be damaged beyond repair before the pest makes itself known. Signs of damage include dark, discoloured, or dead areas and branches. Sap and sawdust–like borings may cling to bark and litter the ground.

Borers also provide an entrance for disease–causing fungi. They can weaken trees, making wind damage likely, and—at worst—can girdle and kill the tree.

Gall Makers

Galls are abnormal vegetative growths produced by a plant in response to insect irritations or stimuli. Causes include feeding, stinging, egg laying, or toxin injection. This reaction generally benefits the pest, rather than the tree, by creating a protected feeding site.

Aphids, mites, midges, gall wasps, and some beetles and moth larvae all can produce galls. Galls vary greatly in size, colour, and complexity, but each insect species produces a characteristic gall formation. Oaks and hickories are the favourite hosts for several hundred different gall insects.

Galls may form anywhere on a tree. They adversely affect the appearance and shape of trees, and may kill leaves and branches. However, galls rarely kill a whole tree.

Soil Pests

Pests below the soil line can damage plants badly before making themselves known. It can be difficult to determine the extent of the pest problem or the effectiveness of treatment.

Some common types of soil pests are listed below; a comprehensive table appears later in this section.

Japanese Beetles

Japanese beetles are regarded as a quarantined pest by the Canadian Food Inspection Agency. While not a major cause of crop damage in Ontario, it's important to control infestations and prevent new ones. Established populations exist in *Hamilton–Wentworth, Haldimand–Norfolk*, and *Niagara* regions.

Japanese beetle larvae are "C"–shaped milky–white grubs about 25 mm long. They have brown heads and 3 pairs of legs. A V–arrangement of abdominal spines distinguishes them from other grubs. The larvae feed on the roots of turf and nursery stock.

Managing Japanese Beetles in Nurseries

If Japanese Beetles infest (or are thought to infest) your area, or adult beetles are caught nearby, use these strategies to reduce injury and control grub populations:

- Watch for emerging adult beetles. The OMAFRA *Nursery–Landscape Hotline*, 1-800-290-4441 will report when adult beetles have been found. (Also found at www.gov.on.ca/omafra/english/crops/hort/nursery.html)

- You may trap for adult Japanese beetles beginning in mid–June. Note that traps are used for monitoring — *not* for control. To avoid attracting beetles to your nursery, place traps in nearby pastures, vacant fields, or fence rows. Research shows that if you trap fewer than 4,000 beetles at peak flight, you probably do not have an established larvae population (especially in clean cultivated soils).

- Scout fences and hedgerows once adult beetles emerge. Look for beetles feeding on leaves, especially in early morning or late afternoon. Feeding injury skeletonizes the leaf.

- Remove wild grape and other weedy host plants from the area. Adult beetles feed on different host plants than their larvae. By removing food sources, you discourage adult beetles from feeding in the area. For a list of common host plants, see OMAFRA Factsheet *Japanese Beetle in Nurseries and Turf*, Order No. 92-105.

- Control beetles in fence rows and hedges first. If you notice beetles feeding, apply controls before 7:00 a.m., when beetles are sluggish and slow. *Sevin* and *Imidan* are registered control products.

- Discourage egg laying in your nursery. Japanese beetles lay eggs in turf areas such as pastures and grassy, weedy areas. Almost all grasses support larval populations, while alsike clover, crown vetch, white Dutch clover, and Canadian mammoth clover do not. Eliminate suitable egg–laying sites near desirable host plants.

- If you maintain a grass strip between tree rows, consider an alternate cover crop. Research shows that you can discourage egg laying by allowing the grass to grow longer in July and August.

- Keep soil that will be dug with the plant at harvest free from weeds and grass. Provide an extra–wide clean cultivated area at the base of trees.

- Cultivating to a depth of 3 in. will destroy 25%–30% of the eggs. Cultivating is most effective in early fall and late spring.

- During droughts, low, wet, poorly drained areas and irrigated fields are preferred egg laying sites.

- Prepare "trap-turf" areas, grassy areas at the periphery of fields that attract egg laying adults. Treat these areas with insecticides in the late summer and early fall to control larvae.

- Containers are not preferred egg-laying sites. Avoid introducing eggs into a container — ensure that added soil is free of Japanese beetle eggs and larvae.

- Maintain a good weed control program in the field and in the container.

- For container grown stock: you can treat in April and May. Alternatively, submerge the entire root ball or container in a solution of 45 ml *Dursban Turf Insecticide* to 10 L of water (4.5 L/1,000 L) until all bubbling stops. Remove plants from the solution and allow them to drain.

Nematodes

Nematodes are tiny, thread–like roundworms that feed and multiply in or on a wide range of plant roots. Necrosis (small dead areas) or localized swellings in roots may indicate possible feeding sites. Nematodes may also spread soil–borne viruses and permit the development of secondary bacteria and fungus infections.

Treat potential nematode problem areas before planting using registered products such as *Vorlex, Basamid, Vapam, Telone*, or *methyl bromide*. Use these materials according to the manufacturer's instructions. Control nematode diseases by rotating crops, sterilizing the soil, and disinfecting dormant planting material. To sample for nematodes, see *Diagnostic Services, Appendix E.*

Consult the OMAFRA Nursery Crop Specialist for detailed information about nematode problems, preplant soil fumigation, and the fumigation of established nurseries. See *Soil Fumigation*, page 79, for more information.

Soybean cyst nematode

Soybean cyst nematode, *Heterodera glycines*, is a concern in southwestern Ontario, especially in *Kent, Perth, Elgin, Essex, and Prescott-Russell* counties. While most field-grown nursery stock does not host this pest, practice good soil management to help reduce its spread.

- Don't grow nursery stock on fields recently used to produce soybeans.

- Don't employ equipment used to work soybean fields. Attached soil can spread the cysts.

- Prevent soil erosion.

- Many weeds act as host plants to soybean cyst nematode. Good weed control will reduce populations.

- Nematicides are ineffective against this pest. For more information, see the OMAFRA Factsheet *Soybean Cyst Nematode*, Order No. 90-119.

Ontario Insect Calendar

The following pages describe common insect pests present during each month of the Ontario growing season. Use this calendar to monitor insect development and employ pest control methods effectively.

Cultural, biological, and chemical pest controls are most effective when applied to the appropriate crops and soils, in the correct way, and at the right time(s).

- If cultural and biological methods can prevent a problem, chemical sprays may represent a needless expense.
- It makes no sense to apply chemicals that control a stage of insect development if that stage is not present.

TABLE 3–3. April Insect Calendar

Pest	Development Stage*	Host-Plant
Defoliators		
Eastern tent caterpillar	Overwintering egg mass	apple, crabapple, cherry, plum
European pine shoot moth	Larva	pine
Gypsy moth	Overwintering egg mass	oak, poplar, birch, various hardwoods and conifers
Viburnum leaf beetle	Overwintering eggs	European highbush cranberry and selections, arrowwood viburnum
Sucking Insects		
Cottony maple scale	Immature female	maple, ash, beech, locust, oak, sycamore, willow
Crimson erineium mite	Adult	silver maple, sugar maple, red maple
Euonymus scale	Mature female	pachysandra, evergreen, deciduous euonymus, bittersweet, English ivy, lilac
European red mite	Egg	apple, crabapple, mountain ash
Fletcher scale	Nymph	white cedar, yew
Lecanium scale	Nymph	ash, beech, boxwood, cedar, elm, hawthorn, honeylocust, locust, maple, oak, yew, and other deciduous plants
Pearleaf blister mite	Adult	mountain ash, serviceberry, cotoneaster, pear, apple
Gall Formers		
Ash flower gall mite	Adult	white ash
Cooley spruce gall adelgid	Nymph	blue Colorado spruce, Douglas fir
Eastern spruce gall adelgid	Nymph	Norway spruce, white spruce, red spruce, black spruce, Engelmann spruce
Maple bladder gall mite	Adult	silver maple, red maple
Maple spindle gall mite	Adult	sugar maple, silver maple, red maple

* Development stage refers to life stage of insect found during that month, and may not be proper timing for control.

TABLE 3–4. May Insect Calendar

Pest	Development Stage*	Host-Plant
Defoliators		
Birch leaf miner	Larva	birch
Cedar leaf miner	Larva	white cedar
Eastern pine shoot moth	Adult	pine
Eastern tent caterpillar	Larva	apple, crabapple, cherry, plum
European pine sawfly	Larva	scotch pine, red pine, jack pine, mugo pine
Forest tent caterpillar	Larva	poplar, sugar maple, oak, ash, birch
Honeylocust leafhopper	Nymph	honeylocust
Imported willowleaf beetle	Larva	poplar, willow
Juniper webworm	Larva	juniper
Lilac leaf miner	Larva	lilac, ash, privet, euonymous, deutzia
Linden looper	Larva	linden, oak, birch, maple, elm, hickory, apple
Spring cankerworm, Fall cankerworm	Larva	lilac, ash, mountain ash, privet, various species
Viburnum leaf beetle	Larva	European highbush cranberry and selections, arrowwood viburnum
Sucking Insects		
Honeylocust plant bug	Nymph	honeylocust
Oystershell scale	Crawler	lilac, apple, ash, beech, birch, cotoneaster, dogwood, elm, linden, maple, poplar, willow
Pearleaf blister mite	Nymph, adult	mountain ash, serviceberry, cotoneaster, pear, apple
Spruce spider mite	Nymph	spruce, cedar, juniper, hemlock, larch, some pines

TABLE 3–4. May Insect Calendar (cont'd)

Pest	Development Stage*	Host-Plant
Borers		
Bronze birch borer	Larva	birch
Eastern pine shoot borer	Adult	pine
Gall Formers		
Cooley spruce gall adelgid	Nymph	Colorado spruce, Douglas fir
Eastern spruce gall adelgid	Nymph	Norway spruce, white spruce
Honeylocust pod gall midge	Adult	honeylocust

* Development stage refers to life stage of insect found during that month, and may not be proper timing for control.

TABLE 3–5. June Insect Calendar

Pest	Development Stage*	Host-Plant
Defoliators		
Birch leaf miner	Larva	birch
Birch skeletonizer	Larva	birch
Cedar leaf miner	Adult	white cedar
Euonymus webworm	Larva	euonymus
European pine sawfly	Larva	pine
European pine shoot moth	Adult	Scotch pine, red pine, mugo pine
Gypsy moth	Larva	oak, poplar, birch, others
Imported willowleaf beetle	Larva	willow, poplar
Lilac leaf miner	Larva	lilac, ash, privet, euonymus, deutzia
Mountain ash sawfly	Larva	mountain ash
Oak skeletonizer	Larva	various oaks
Pear sawfly	Larva	hawthorn, mountain ash, serviceberry, cherry, plum, pear, flowering quince
Rose chafer	Adult	rose, mountain ash, elm, oak, birch, sumac, hawthorn, spirea, alder, pine, others
Spiney elm caterpillar	Larva	elm, willow, birch, maple, mountain ash, other deciduous trees
Spruce needle miner	Larva	spruce
Viburnum leaf beetle	Larva	European highbush cranberry and selections, arrowwood viburnum
Yellow headed spruce sawfly	Larva	spruce
Sucking Insects		
Euonymus scale	Crawler	euonymus, bittersweet, English ivy, lilac, pachysandra
Juniper scale	Crawler	juniper
Oystershell scale	Crawler	lilac, apple, ash, beech, birch, cotoneaster, dogwood, elm, linden, maple, poplar, willow
Pear leaf blistermite	Nymph, adult	mountain ash, serviceberry, cotoneaster, pear, apple
Two spotted spider mite	Nymph, adult	various
Borers		
Pine root collar weevil	Adult	Scotch pine, Austrian pine
Poplar willow borer	Larva	willow, poplar, alder, birch

* Development stage refers to life stage of insect found during that month, and may not be proper timing for control.

TABLE 3–6. July Insect Calendar

Pest	Development Stage*	Host-Plant
Defoliators		
Birch leaf miner	Larva	birch
Birch skeletonizer	Larva	birch
Cedar leaf miner	Adult	white cedar
Euonymus webworm	Larva	euonymus
European pine sawfly	Larva	pine
European pine shoot moth	Adult	Scotch pine, red pine, mugo pine
Gypsy moth	Larva	oak, poplar, birch, others
Imported willowleaf beetle	Larva	willow, poplar
Lilac leaf miner	Larva	lilac, ash, privet, euonymus, deutzia
Mountain ash sawfly	Larva	mountain ash

TABLE 3–6. July Insect Calendar (cont'd)

Pest	Development Stage*	Host-Plant
Oak skeletonizer	Larva	various oaks
Pear sawfly	Larva	hawthorn, mountain ash, serviceberry, cherry, plum, pear, flowering quince
Rose chafer	Adult	rose, mountain ash, elm, oak, birch, sumac, hawthorn, spirea, alder, pine, others
Spiney elm caterpillar	Larva	elm, willow, birch, maple, mountain ash, other deciduous trees
Spruce needle miner	Larva	spruce
Viburnum leaf beetle	Larva	European highbush cranberry and selections, arrowwood viburnum
Yellow headed spruce sawfly	Larva	spruce
Sucking Insects		
Euonymus scale	Crawler	euonymus, bittersweet, English ivy, lilac, pachysandra
Juniper scale	Crawler	juniper
Oystershell scale	Crawler	lilac, apple, ash, beech, birch, cotoneaster, dogwood, elm, linden, maple, poplar, willow
Pear leaf blistermite	Nymph, adult	mountain ash, serviceberry, cotoneaster, pear, apple
Two spotted spider mite	Nymph, adult	various
Borers		
Pine root collar weevil	Adult	Scotch pine, Austrian pine
Poplar willow borer	Larva	willow, poplar, alder, birch

* Development stage refers to life stage of insect found during that month, and may not be proper timing for control.

TABLE 3–7. August Insect Calendar

Pest	Development Stage*	Host-Plant
Defoliators		
Apple & thorn skeletonizer	Larva	apple, crabapple, plum, hawthorn, quince
Cedar leafminer	Larva	cedar
Fall webworm	Larva	ash, Manitoba maple, flowering crab, various shade trees
Japanese beetle	Adult	roses, wild grape, linden, birch, willow, cherry, other deciduous plants
Mountain ash sawfly	Larva	mountain ash
Oak skeletonizer	Larva	various oak species
Viburnum leaf beetle	Adult	European highbush cranberry and selections, arrowwood viburnum
Zimmerman pine moth	Larva	pine
Borers		
Locust borer	Adult	black locust
Poplar and willow borer	Adult	poplar, willow

* Development stage refers to life stage of insect found during that month, and may not be proper timing for control.

TABLE 3–8. September Insect Calendar

Pest	Development Stage*	Host-Plant
Defoliators		
Apple & thorn skeletonizer	Larva	apple, flowering crabapple, purple plum, hawthorn, quince
Fall webworm	Larva	ash, Manitoba maple, flowering crab, various shade trees
Mountain ash sawfly	Larva	mountain ash
Borers		
Locust borer	Adult	black locust
Poplar and willow borer	Adult	poplar, willow
Gall Formers		
Cooley spruce gall adelgid	Adult	spruce, Douglas fir

* Development stage refers to life stage of insect found during that month, and may not be proper timing for control.

Diseases Affecting Trees and Shrubs

Diseases are broadly classified according to the types of damage they cause to woody plants.

- Foliage diseases
- Crown and root rots
- Cankers
- Vascular wilts
- Viruses
- Abiotic diseases

Diseases arise from many causes such as bacteria, fungi, molds, viruses, and environmental conditions. Some common nursery and landscape plant diseases are listed below; a comprehensive table begins on page 39.

Foliage Diseases

Most disease symptoms appear first in plant foliage. However, damaged foliage may not imply a "leaf disease." Leaves may wilt, turn yellow or brown, spot, drop off, or deform due to diseases not directly associated with the leaves. For example, plant foliage can change in response to vascular wilts or cankers elsewhere on the plant. Non–infectious agents, such as drought and air pollution, also display their first symptoms in the foliage.

Downy mildew, powdery mildew, leaf spots, anthracnose, and *needlecast* are common diseases that infect foliage directly. *Rust* diseases that cause leaf spots on broadleaf hosts are discussed under "cankers."

Botrytis (Grey Mold)

This disease, caused by the fungus *Botrytis* cinera, can affect bulbs, stems, leaves, and flowers. It often attacks open or fading flowers and leaves, succulent soft growth, and damaged tissue. Symptoms vary from host to host. In very humid air, *Botrytis* causes a fuzzy grey growth on infected plant parts.

High humidity promotes *Botrytis* outbreaks. Reduce humidity by providing good air circulation around your plants. Remove all fading, senescing, and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day, and never leave old leaves or flowers on plants or on the surrounding soil surface.

Downy Mildew

Downy mildew appears early in the season. It often covers the undersides of leaves with a heavy, white, downy fungus growth. Discoloured, purplish spots may appear on the surface of the leaves.

Warm or cool wet weather and poor air circulation promote downy mildew. Reduce humidity by providing good air circulation around your plants. Remove all fading, senescing, and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day, and never leave old leaves or flowers on plants or on the surrounding soil surface.

Powdery Mildew

Several species of fungi cause powdery mildew. Powdery mildews produce powdery white mats on upper leaf surfaces and young tissue. Wind–borne spores can cause secondary infections, though individual species don't spread readily from one kind of plant to another.

Powdery mildew usually appears after mid-season when warm days follow cooler nights. It affects many woody ornamentals, such as lilac, rose, privet, and catalpa. Because the fungus grows mainly on the plant surface, it can be controlled with fungicides. In some cases, as with roses, severe deformation requires control. In others, such as with lilacs and privets, the disease is not damaging enough to warrant fungicide applications.

To reduce powdery mildew, place plants in sunny locations with good air circulation. Where possible, plant resistant cultivars. Overhead watering *during the day* reduces the spread and development of powdery mildew. However, avoid overhead irrigation late in the day.

Leaf Spot and Anthracnose

"Anthracnose" refers to several plant diseases that cause dead spots on leaves or fruits. This disease may also affect the twigs, causing a canker and dieback. Infected areas may coalesce into large necrotic spots as the disease spreads. In severe cases, this condition defoliates the plant. Leaf spotting, itself, is not harmful. However, extensive annual defoliation can lead to plant decline and death.

Cool, wet, dull spring weather promotes infection by fungi that cause leaf spot and anthracnose. Catalpa, poplar, walnut, hickory, hawthorn, maple, oak, sycamore, mock orange, mountain ash, and horse chestnut are common hosts. Sycamore anthracnose caused by the fungus *Gnomonia plantani* can be severe in Ontario and has killed many trees in the eastern United States.

Needlecast

Needlecast diseases are fungi affecting pines (Pinus), spruce (Picea), and firs (Abies). New needles generally become infected just after the new growth starts. Characteristic black fruiting bodies then develop along the needles. Needles infected the previous season are "cast" (i.e., fall off) during the summer. Needlecast can be serious in 1–4 yr. old plants at Ontario tree nurseries.

Scab

"Scab" describes a fungus disease on fruit, though a leaf spot similar to rose blackspot has the same cause. Diseases causing scab–like lesions occur frequently on rosaceous plants (e.g., crabapples).

Apple Scab

Apple scab, *Venturia inaequalis*, has defoliated crabapples extensively when cool, wet weather occurs in May and June. Control apple scab through cultural practices. Plant the trees in open sunny areas with good air movement and maintain their health. Prune the trees regularly to encourage quick leaf drying. Since the disease overwinters on fallen leaves, collect these leaves in the late summer and fall each year. Remove the collected leaves from the growing area. (This practice may prove ineffective if other diseased trees exist in the area.)

With proper culture, apple scab rarely requires chemical control. Where possible, plant scab resistant crabapple selections. If scab problems do appear, spray registered fungicides preventively. Apply the first spray when the green leaf tips appear. Repeat every 5–7 days until July 1-. If no scab appears by July 1-, stop spraying. If scab is visible, continue fungicide applications every 10–14 days until mid–August.

Pyracantha scab

Pyracantha scab, *Venturia pyracanthae*, destroys the fruit of susceptible firethorn varieties. Spraying is necessary most years. The cultivars "Orange Glow," "Orange Charmer," and "Mohave" resist this scab.

Crown and Root Rots

Soil fungi such as *Pythium* and *Phytophthora* cause the roots and crowns of many plants to rot. The lower leaf parts, petioles, and stems of diseased plants develop a water soaked appearance. Eventually the plant rots off at ground level.

Rhizoctonia and *Fusarium* fungi cause a brown cankering of plant stems and roots below ground.

Thielaviopsis causes severe root rot in infected plants — the affected areas are more black than brown. When this condition affects seedlings, the disease is called "damping-off."

Cankers

Cankers kill bark and cambial tissues in localized branch and stem areas. Bark in affected areas splits as it dries and is easily removed, exposing the wood below. This, in turn, kills the underlying cambium and wood. Fruiting "pustules" of the disease organism usually form on the dead bark areas. Cankers may girdle a stem or branch, killing remote portions of the plant.

Canker diseases can be annual or perennial. They commonly damage hosts weakened by factors such as drought, poor hardiness, root disturbance, or a poor root environment. Weak, parasitic fungi (species of *Cytospora*, *Nectria*, *Valsa*, and *Hypoxylon*) cause damaging canker diseases that a healthy, vigourous host would resist (by "sealing off" the infecting agent). While fungi account for most cankers, sunscald and frost also cause them.

Some canker diseases (e.g., *white pine blister rust*, *chestnut blight*, and *butternut canker*) are very serious. "Monoculture" growing systems used in plantations and forest nurseries may also promote serious canker diseases.

Chemical control for canker diseases is rarely recommended, since removing cankered areas controls most cankers. Try pruning diseased branches well below the affected areas. Improve host health and vigour via cultural means for long term control.

Rust

Rust diseases involve fungi that cause reddish–brown (rusty) spots on leaves, twigs, or stems. They frequently distort the shape of infected plant parts. Some rusts have 1 host plant. However, most rusts require 2 hosts, each at a different phase of their life cycle. Both hosts are necessary for the disease organism to thrive. In these cases, 1 host plant may be severely damaged while the other suffers little damage or none.

Fire Blight

Fire blight, a bacterial disease caused by *Erwinia amylovora*, affects many members of the *Rosaceae* family including *Amelanchier*, *Aronia*, *Chaenomeles*, *Cotoneaster*, *Crataegus*, *Malus Photinia*, *Prunus*, *Pyracantha*, *Pyrus*, *Sorbus*, and *Spiraea*. Flowers, spurs, twigs, and leaves turn brown and dry out. Dead leaves remain on the plant and appear scorched. In warm, humid weather, an amber material may exude from recently infected parts. Bleeding perennial cankers may appear on limbs, trunks, or roots as the infection spreads. Rain, wind, and insects can spread this disease from plant to plant.

Control fire blight by pruning cankers 0.3 m [1 ft.] below the affected area and removing nearby infection sources (e.g., neglected pear trees). Bactericidal sprays at flowering may be helpful.

Crown Gall

The bacterium *Agrobacterium tumefaciens* causes rough, irregular galls up to several centimetres in size. Crown gall can affect most woody plants, including rosaceous hosts, euonymus, and nut trees. It occurs mainly near the soil line at the root collar, but also on roots and aerial parts. While not a "true" canker disease, crown gall is included here because it disrupts plant vascular systems so that girdling results.

The bacterium enters through wounds (e.g., from a disc, hoe, or grafting knife) and can live in the soil without host plants for about 2 yrs. Nurseries should use sanitary propagation practices, such as sterilized grafting tools. Replace infested soils or leave them fallow for 2 yrs. before replanting. Chemical controls are not recommended.

Do not accept plants from a nursery if you find suspicious bumps on the scaffold roots, especially on roses and fruits.

Vascular Wilts

Fungi or bacteria entering a plant's vascular system can reduce water supplied to the leaves, causing wilt. In a wilt's early stages, leaves often recover temporarily during cool, moist periods. Eventually, the wilt becomes established and the leaves and twigs die. This leads to branch mortality and the eventual death of the entire plant. Serious vascular wilt diseases include "Dutch elm disease" caused by the fungus *Ceratocystis ulmi* and *Verticillium* wilt of maple, linden, and catalpa caused by *Verticillium dahliae.*

To avoid wilt diseases, use resistant varieties where available and plant in disease–free soil. See Table 3-9, *Woody Plants Susceptible to Verticillium Wilt.* You can sometimes maintain *Verticillum* wilt–infected plants by improving vigour through pruning, fertilizing, and watering. Since these disease organisms live deep inside the plant, you cannot successfully apply surface chemical controls.

Virus Diseases

Virus diseases appear on plants as mottled yellow foliage, misshapen or wrinkled leaves, aborted flowers, or stunted growth. You must remove these diseased plants and destroy them.

TABLE 3–9. Woody Plants Susceptible to Verticillium Wilt

Acer	maple
Aesculus	buckeye, horsechestnut
Amelanchier	serviceberry
Buxus	boxwood
Calluna	heath
Catalpa	catalpa
Ceris	red bud
Cladrastus	yellowwood
Cotinus	smokebush
Daphne	daphne
Eleagnus	Russian olive
Fraxinus	ash
Gymnocladus	Kentucky coffee tree
Hibiscus	hibiscus
Kolreutria	golden rain tree
Ligustrum	privet
Liriodendron	tulip tree
Lonicera	honeysuckle
Magnolia	magnolia
Phellodendron	cork tree
Prunus	cherry and other stone fruit
Rhododendron	azalea
Rhus	sumac
Ribes	currant, gooseberry
Robinia	black locust
Rosa	rose
Sambucus	elder
Spireae	spirea
Syringa	lilac
Ulmus	elm
Viburnum	viburnum
Vitis	grape vine
Wiegela	wiegela

TABLE 3–10. Woody Plants Resistant to Verticillium Wilt

All monocots (grass like) plants	
All conifers	
The following broadleaf plants:	
Betula	birch
Carya	hickory
Celtis	hackberry
Cercidiphyllum	katsura tree
Chaenomeles	flowering quince
Cornus	dogwood
Crataegus	hawthorn
Fagus	beech
Gleditsia	honeylocust
Ilex	holly
Juglans	bitternut, walnut
Liquidumbar	sweetgum
Malus	apple, crabapple
Morus	mulberry
Platanus	plane tree, sycamore
Populus	poplar
Pyracantha	firethorn
Pyrus	pear
Quercus	oak
Rhododendron	rhododendron
Salix	willow
Sorbus	mountain ash
Tilia	linden
Zelkova	Japanese zelkova

Insects and infected tools (e.g., pruning equipment, knives, shears) spread most of the virus diseases. *You cannot control viruses directly by chemical means.* When you suspect a virus, disinfect all tools and implements before using them again. Controlling aphids, leafhoppers, mites, and other migratory insects also helps prevent viral spread. Virus diseases include:

Ash yellows

Plants show reduced growth, stunting, and smaller leaves. Symptoms can vary with the age of the plant. In some cases, plants develop chlorotic leaves and witches brooms.

Elm yellows

Leafhoppers probably transmit these mycoplasma–like organisms. Leaves of infected trees begin to turn yellow by mid–summer and to twist and droop (epinasty). The leaves often fall, and the branch dies shortly after.

Rose mosaic

Rose mosaic symptoms can include leaf discoloration, chlorotic mottling, ringspots, light green or chlorotic line patterns, vein clearing, banding, and white or yellow mosaics. Specific symptoms vary with the cultivar, the environment, and the strain of virus.

Abiotic Diseases

Abiotic diseases principally affect foliage and/or root system function. These diseases cause many plant problems, often predisposing affected plants to infection by secondary disease organisms. Gradual dieback and mortality can occur.

Weather, soil conditions, and human environmental disturbances cause these conditions. Control measures depend on eliminating or avoiding damaging factors (e.g., salt injury), obtaining resistant plants, and improving growing conditions.

Root scorch from high soil salt levels is a common abiotic condition. It comes from salty irrigation water or from salt applied to remove ice and snow. A late–spring leaf scorch of maple and beech may come from sudden exposure to full sunlight after a cloudy, wet period.

The ability of a plant to accommodate environmental change varies with the type of plant, its age and condition, and the nature and intensity of the changes. Oak, maple, ash, and spruce have difficulty adjusting to new conditions such as soil compaction, drought, excessive water, change in soil level, or root damage during construction.

Understanding Dieback

Nursery and landscape plants often exhibit dieback. This may affect individual branches or entire plants. Dieback may appear suddenly, or develop so gradually that the true impact doesn't show for several years.

Environmental and cultural problems causing dieback include girdling wires, strings, and ropes left on after transplanting, root problems, soil conditions, waterlogging, changes in soil grade, sun scald, and low temperatures.

Insects and diseases can also cause dieback symptoms. Examples include scales, wood boring insects, bark boring insects, root feeding weevil and white grub larvae, cankers, rusts, fire blight and vascular wilts.

Fall Needle Drop of Conifers

As shorter, cooler autumn days approach, older needles towards the inside of many conifers begin to turn yellow or brown. In some cases, these needles start to drop. This is usually, but not always, a natural process. The degree of discoloration and drop may relate to stress during the growing season. Low vigour caused by drought, transplanting, poor drainage, soil compaction, insects, and disease make needle drop worse.

- Pines lose their oldest needles, closest to the trunk. White pines, *Pinus strobus*, often look quite yellow.

- Small branchlets towards the inside of white cedar, *Thuja occidentalis*, turn brown and fall off.

- Fir, *Abies*, and spruce, *Picea*, may lose needles on 1–3 yr. old wood.

Needle Browning on Conifers

Winter damage may cause conifer needles to brown and shed in the spring. Many factors can lead to this condition, especially dry, windy weather while the soil is frozen. The wind causes water loss, and roots don't absorb enough water from the frozen soil to compensate.

Good health and growing conditions during the previous growing season help plants resist winter damage. Roots in the upper soil surface are sensitive to drying and high temperatures. If these roots die during the growing season, poor conditions may prevent sufficient regrowth to recover winter moisture losses.

Salt Damage

Road salt affects woody plants from both runoff and airborne drift. When plant tissues are wet and temperatures are above freezing, sodium and chloride from salt enter plant tissues and accumulate. Repeated road salt injury weakens plants, making them susceptible to damage from many insects and diseases.

Drifting salt spray causes more plant damage than runoff. It can affect plants located 50+ metres away from a road. Symptoms appear more quickly in warm weather, and are usually more severe on the side facing the road.

Salt Damage Symptoms on Conifers

- needle browning, beginning at the tip
- needle browning and twig dieback on the side facing the road, but little or none on the opposite side
- no needle browning or dieback on branches near the ground under continuous snow cover
- needle and twig dieback is less severe further from the road
- browning appears in late–February or early–March and becomes more obvious through spring and summer

Salt Damage Symptoms on Deciduous Plants

- slow bud break on terminal parts of branches facing the road
- leaves fail to emerge on terminal parts of branches facing the road
- new growth on branches facing the road develops from the lower portions, causing a tufted or witches broom appearance
- flower buds on the road side do not open; normal flowering on plants further away from the road
- injury becomes evident as buds begin to break

Scorch

Scorch happens when plants have difficulty taking up water. It appears as sudden leaf death or browning on leaf margins or between leaf veins, often in mid–August. The veins frequently remain green.

Plants experiencing root injury due to construction, soil compaction, chemicals, drought, or extreme heat can show symptoms of scorch.

Endosulfan and Thiodan are very toxic to fish. Do not apply these products on or near water.

Treating Tree and Shrub Pests with Insecticides and Fungicides

Toxicity Information

The "relative toxicity" of a pesticide is called its LD_{50}. The higher the LD_{50} value of a chemical, the less toxic the product is to humans.

LD_{50} is the chemical's active ingredient (*a.i.*) in mg/kg of test animal body weight that kills 50% of the test animals (usually female rats). LD_{50} is commonly measured as the *Acute Oral* LD_{50}, which means the chemicals are ingested through the mouth or nose. *Dermal* LD_{50} (skin penetration) toxicity values are available on request.

Chemical Families

Most agricultural chemicals belong to a chemical "family," a group of substances that share important characteristics.

The product tables on the next pages list chemical families using abbreviations. The full chemical family names and their associated abbreviations appear here.

TABLE 3–11. Chemical Families

An	aliphatic nitrogenous compound
Arom	aromatic hydrocarbon
Ben	benzimidazole
Dicarb	dicarboximide
Dinitro	dinitrophenol
Dithio	dithiocarbamate
EBI	ergosterol biosynthesis inhibitor
Morph	morphactin
OC	organochlorine
OP	organophosphorous
Org	organatin
OX	oxithin
Ph	phthalimide
R	rodenticide
Syn.Pyr.	synthetic pyrethroid
Thia	thiadiazole
Tri	triazole

Pesticide Application Restrictions

It's important to observe restrictions on pesticide application. OMAFRA recommends only registered agricultural chemicals. However, registration doesn't mean a product is safe for everyone to use. While some products may be applied by anyone, most are subject to restrictions on use. Restrictions are listed by "schedule number". See Table 3-13, page 38.

TABLE 3–12. Insecticides and Fungicides Used to Protect Ornamentals (by Product Name)

Product Name	Type	Schedule	Common Name	Oral LD$_{50}$ (mg a.i./kg) **	Chemical Family
Agri-Mycin 17		3	streptomycin sulphate		
Alamo	I	2	propiconazole	2100	Tri
Ambush	I	3	permethrin	4000+	Syn. Pyr
APM	I	5	azinphos-methyl	20	OP
Bordeaux	F		spray tank mix of copper sulphate, hydrated lime, and waters		
Botran	F	3	dichloran	10,000+	Dicarb
Captan	F	2	captan	9000	Ph
Copper 53W	F	3	tri–basic copper sulphate		
Copper Spray	F	3	copper oxychloride		
Cygon	I	2	dimethoate	215	OP
Cymbush	I	2	cypermethrin		
Cyprex	F	3	dodine	1000	AN
Daconil 2787	F	3	chlorothalonil	10,000+	Arom
Danex	I	3	trichlorfon	560	OP
Diazinon	I	2	diazinon	300	OP
Dipel	I	3	bacillus thuringiensis	non-toxic	Biological
Disyston	I	2	disulfoton	5	OP
Dithane DG	F	3	mancozeb	5000+	Dithio
Dithane M-45	F	3	mancozeb	6750	Dithio
Dithane Z-78	F	3	zineb	5000+	Dithio
Dursban	I	3	chlorpyrifos	135	OP
Dygall	F				
Dylox	I	3	trichlorfon	560	OP
Dyrene	F	3	anilazine	5000+	Arom
DZN 600	I	2	diazinon	300	OP
Easout	F	3	thiophanate methyl	7500	Ben
Endosulfan	I	2	endosulfan	110	OC
Ferbam	F	3	ferbam	17,000+	Dithio
Folpan	F	3	folpet	10,000	Ph
Foray	I	3	bacillus thuringiensis	non-toxic	Biological
Funginex	F	3	triforine	16,000+	EBI
Ground Force	R		chlorophacinone	2.1	
Guthion	I	5	azinphos-methyl	20	OP
Imidan	I	3	phosmet	300	OP
Karbam Black	F	3	ferbam	17,000+	Dithio
Kelthane	A	2	dicofol	684	OC
Lagon	I	2	dimethoate	215	OP
Lannate	I	2	methomyl	17	Carbamate
Malathion	I	3	malathion	1400	OP
Manzate 200	F	3	mancozeb	6750	Dithio
Meltatox	F		dodemorph	4500	
Metaldehyde bait		3	metaldehyde	630	Metaldehyde
Methoxychlor	I	3	methoxychlor	6000	OC
Morestan	I	3	chinomethionat	2500	Carbonate
Moxy	I	3	methoxychlor	6000	OC
Orthene	I	3	acephate	866	OP

I = Insecticide; F = Fungicide; R = Rodenticide; A = Acaricide

TABLE 3–12. Insecticides and Fungicides Used to Protect Ornamentals (by Product Name) (cont'd)

Product Name	Type	Schedule	Common Name	Oral LD$_{50}$ (mg a.i./kg) **	Chemical Family
Orthocide	F	2	captan	9000	Ph
Pentac	A	3	dienochlor	3160	OC
Phaltan	F	3	folpet	10,000	Ph
Pirimor	I	2	pirimicarb	147	Carbamate
Polyram	F	3	metiram	10,000+	Dithio
Pounce	I	3	permethrin	4000+	Syn. Pyr
Pyrate	I	3	chlorpyrifos	135	OP
Ramik Brown, Ramik Green	R R	3	diaphacinone	3	
Ratak+	R	2	brodifacaum	0.27	
Rodent Bait, Rodent Pellets	R R	1,2	zinc phosphide	45	
Rovral	F	3	iprodione	3550	
Rozol	R		chlorophacinone		
Safers' Insecticidal Soap	I				
Sevin	I	3	carbaryl	560	Carbamate
Sniper	I	5	azinphos-methyl	20	OP
Stauffer C	F	2	captan	9000	Ph
Sumithion	I		fenitrothion		
Thiodan ****	I	2	endosulfan	110	OC
Thionex	I	2	endosulfan	110	OC
Thiram	F	3	thiram	780	Dithio
Thuricide	I	3	bacillus thuringiensis	non-toxic	Biological
Vendex	A	3	fenbutatin oxide	2631	Organotin
Waxed Mouse Bait	R	1,2	zinc phosphide	45	
Zineb	F	3	zineb	5000+	Dithio

I = Insecticide; F = Fungicide; R = Rodenticide; A = Acaricide

TABLE 3–13. Pesticide Schedules

Schedule 1	Restricted use by permit only
Schedule 2	Restricted to agriculturists, licensed exterminators, and custom sprayers
Schedule 3	May be available for "domestic" purposes if so registered
Schedule 4	"Domestic" products only
Schedule 5	Limited to application on agricultural land
Schedule 6	"Domestic" similar to Schedule 4, but may be registered for agricultural/ commercial use

A Compendium of Pests and Diseases with Recommended Treatments — 2000

Listings appear alphabetically by plant genus. Control products listed appear alphabetically. All listed products are registered for the listed purpose. The order in which products appear does not constitute a preference ranking.

See colour plates at the back of the book for photos of plant pests.

ABIES — fir

	Pest	Control/1000 Litres water	Remarks
INSECTS	Balsam twig aphid *(Mindarus abietinus)*	➢ DZN 600EW (See product label) ➢ Malathion 500EC, 1.25 L	Wear protective clothing. Apply DZN 600EW by mist blower at 1.4 L in 50–100 L of water/ha to ensure thorough coverage of trees. Before spraying, spray trees in a half-hectarea with 50 L of water only, to confirm that coverage is adequate. Feeds on newly developing needles. Easily identified by its waxy, wmvering. Injured needles are curled and twisted. Treat when aphids first appear (early–May) as bud caps begin to loosen.
	Spruce budworm *(Choristoneura fumiferana)*	➢ Ambush 500EC, 35–70 mL ➢ Foray 48B, 1.0–2.4 L/ha ➢ Malathion 500EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Sumithion 50EC, 0.3.5–0.5.6 L	Black head and brownish body with 4 light spots on the back of each segment. **[Plate 1]** Widespread, important defoliator of balsam fir and spruce, beginning to feed as buds break and continuing until mid– to late–June. One generation per year. Apply general coverage spray in mid–May to control larvae
	Tarnish plant bug	➢ See under THUJA.	**[Plate 74]**
	Botrytis	➢ See under THUJA.	
DISEASES	Canker	➢ See under CANKERS	
	Needlecast	➢ Bordeaux mixture 8–8–1000 ➢ Copper spray, 4.0 kg ➢ Daconil 2787F, 2.5 L	Principally a nursery disease. Caused by several fungi having a 2–stage life cycle. Symptoms develop early in the second season. Infected needles turn brown and drop. Badly infected plants have only current season needles. Spray after new growth begins and again 10 days later.

ACER — maple

	Pest	Control/1000 Litres water	Remarks
INSECTS	Aphid	➢ Endosulfan 50W, 1 kg ➢ Thiodan 4EC, 1.25–1.75 L ➢ Dursban 2E, 750 mL ➢ Malathion 500EC, 1.25 L ➢ Orthene 76SP, 1.0 kg ➢ Pyrate 480EC, 375 mL ➢ Sniper 240E, 1.75–2.5 L	Treat when adults first appear and repeat as required. Check under leaves for honeydew and sooty mold. Many natural predators (e.g., Ladybugs, hover flies, lace wings). Pesticides will kill predators. *Orthene* may damage sugar maple leaves. **Endosulfan* and *Thiodan* toxic to fish.
	Cottony maple scale *(Pulvinaria innumerabilis)*	➢ Dursban 2E, 4.0 L ➢ Ethion superior oil, 20 L ➢ Malathion 500EC, 2.5 L ➢ Orthene 76SP, 1.0 kg ➢ Pyrate 480EC, 2.0 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	Mature female scale resembles a partially popped corn kernel. **[Plate 2]** Attacks maple, linden, elm, beech, oak, and other trees and shrubs. Found only on twigs. Use *superior oil* or *Ethion superior oil* as early–spring dormant treatment, *except* on sugar and Japanese maples. Nymphs active first week of July, about when *Philadelphus* and *Tilia cordata* bloom. Cover lower leaf surface with spray. Apply again 10 days later. Don't use *Malathion* on Crimson King maple. *Orthene* may damage sugar maple leaves.

ACER — maple (cont'd)

	Pest	Control/1000 Litres water	Remarks
INSECTS	Forest tent caterpillar *(Malacosoma disstria)*	➤ Ambush 500EC, 70 mL ➤ Dipel 132 ES, 0.5–1.0 L/ha ➤ Dursban 2E, 1.0 L ➤ Foray 48B, 1.0–1.6 L/ha ➤ Orthene 76SP, 1.0 kg ➤ Pyrate 480EC, 500 mL ➤ Sevin XLR PLUS, 2.3–3.5 L ➤ Thuricide, 1.5–2.0 L	Does not form a tent. May completely defoliate broadleaf trees, particularly poplars, over a wide area. Has series of "key–hole" shaped white spots along its back. Present early in the season. Feeds in colonies. **[Plate 3]** Treat foliage mid– to late– May to control larvae. *Orthene* may damage sugar maple leaves.
	Greenstriped mapleworm *(Dryocampa rubicunda)*	➤ Sevin 50W, 2.0–3.0 kg	Cherry red head and yellowish body with seven dark lines running its entire length. Preferred hosts are maple, oak, and box elder. Usually doesn't require control. Eggs hatch over an extended period. If necessary, spray from mid–June to late–July.
	Gypsy moth	➤ See under BETULA.	**[Plate 16 & 17]**
	Japanese beetle	➤ See under ROSA.	**[Plate 62 & 63]**
	Leafhopper	➤ See under MALUS.	
	Lecanium or European fruit lecanium *(Lecanium corni)*	➤ Dursban 2E, 4.0 L ➤ Ethion superior oil, 20 L ➤ Malathion 500EC, 2.5 L ➤ Orthene 76SP, 1.0 kg ➤ Pyrate 480EC, 2.0 L ➤ Sevin XLR PLUS, 2.3–3.5 L ➤ Superior oil, 20 L	A large, reddish–brown, spherical scale usually found on the underside of twigs. **[Plate 4]** Infests many deciduous trees and shrubs. Use *superior oil* or *Ethion superior oil* as early–spring dormant treatment. Spray any of the other materials in late–July. Don't use *Malathion* on Crimson King maple. *Orthene* may damage sugar maple leaves.
	Crimson erineum mite *(Eriophyes regulus)* Maple bladder gall mite *(Vasates quadripedes)* Maple spindle gall mite *(Vasates aceriscrummena)*	➤ Ethion superior oil, 20 L ➤ Malathion 500EC, 2.5 L ➤ Superior oil, 20 L	Crimson erineum mite causes granular red, velvety patches on both sides of sugar, silver, and red maple leaves. Maple bladder gall mite causes globular, wart–like galls on the upper surface of silver and red maple leaves. Heavy infestations may completely deform leaves but seldom injure trees seriously. Maple spindle gall mite produces 5 mm long, slender fusiform galls on the upper surface of sugar and silver maple leaves. Several generations per year. Use *superior oil* or *Ethion superior oil* as an early–spring dormant treatment. *Don't use oil on sugar and Japanese maples.* Apply *Malathion* in spring when temperature is 2° C or higher. Don't use *Malathion* on Crimson King maple.
	Maple petiole borer *Caulocampis acericaulis*	Tunnels in maple leaf stems, causing leaves to break near the blade and fall. To reduce borer populations, collect and destroy infested fallen leaf stems before the larvae leave them.	
	Maple trumpet skeletonizer *Epinotia aceriella*	➤ Methoxychlor 240EC, 4.0 L ➤ Sevin 50W, 2.0–3.0 kg	Normally a minor problem, it attacks sugar, red, and silver maples. Spins a long trumpet–like tube of silk and frass on the underside of a leaf, which folds around it. Feeds from within this tube, skeletonizing the part of the leaf covered by the web. **[Plate 5]** This causes the leaf to crumple. May attack hawthorn and beech. Larvae exist from late–July to Sept. Apply control to bottom leaf surfaces from mid–July to mid–Aug.
	Sugar maple borer *Glycobius speciosus*	Usually a landscape problem, especially on stressed trees. A robust, black, longhorned beetle with five yellow bands on the wing covers. The fleshy white larva cuts deep channels in the wood. Cracked, swollen areas resembling cankers indicate infestation. Has a 2–year life cycle. Females cut a slit into the bark and lay eggs in late July and into Aug. Keep trees vigorous.	
DISEASES	Canker	➤ See under CANKERS	
	Dieback	➤ See ABIOTIC diseases	
	Leaf scorch	➤ See ABIOTIC diseases	**[Plate 61]**
	Leaf spot	➤ See under CATALPA	
	Tarspot *Rhystima acerinum,* *R. punctatum*	Leaves infected in spring during cool, wet weather. Causes irregular black tar–like spots on Norway, red, silver, and sugar maple leaves by mid– to late–summer. **[Plate 6]** Improve air circulation to encourage quick leaf drying. Disease overwinters on fallen leaves—rake and discard leaves in fall.	
	Verticillium wilt	Infection causes sapwood to darken. **[Plate 7]** Prune wilted branches back to healthy wood. Thin remainder of crown. Fertilize and water to promote vigour, especially root growth. Disease often followed by frost cracks and associated cankers. See *Susceptible and Tolerant Plants,* page 34.	

AESCULUS — horse chestnut

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Leaf scorch	➤ See ABIOTIC diseases	
	Anthracnose *(Glomerella cingulata)*	➤ Daconil 2787F, 2.5 L	Leaves infected during cool, wet springs. Encourage good air circulation through the canopy. Don't crowd plants.
	Leaf blotch *(Guignardia aesculi)*	➤ Daconil 2787F, 2.5 L	Large blotchy, reddish–brown lesions surrounded by a yellow halo. **[Plate 8]** Appears on leaves by mid–summer. Leaves often curl and distort. A tree may show symptoms of leaf blotch, scorch, and anthracnose. Leaves infected during cool, wet springs. Encourage good air circulation through the canopy. Don't crowd plants.

BETULA — birch

	Pest	Control/1000 Litres water	Remarks
INSECTS	Aphid *(Calaphis betulaecolens)* Euceraphis punctipennis *(Hamamelistes spinosus)*	➤ Cygon 480E, 625 mL ➤ See under FAGUS	*Calaphis betulaecolens*, a large green aphid, feeds only on birch. *Euceraphis punctipennis*, a black and green aphid, leaves a cottony–white wax on birch and alder. *Hamamelistes spinosus* also affects *Hamamelis* (witch hazel). Feeding nymphs cause corrugated swellings between veins on leaves. Treat when adults first appear; repeat as required. Check underside of leaves for honeydew and sooty mold. Many natural predators (e.g., ladybugs, hover flies, lace wings). Pesticides will kill predators.
	Birch leaf miner *(Fenusa pusilla)*	➤ Cygon 480E, 500 mL ➤ DZN 600 EW, 830 mL ➤ Di–syston, 15% granules (see product label) ➤ Lagon 480, 500 mL ➤ Malathion 500EC, 2.5 L ➤ Orthene 76SP, 1.0 kg ➤ Sevin XLR PLUS, 2.3–3.5 l	Forms a blotch mine covering half or more of each leaf. **[Plate 9]** Foliage of heavily infested trees looks scorched. Two generations a year—second flush of growth is also attacked. Adult, a small black sawfly, emerges from soil when first birch leaves are half grown. First mines appear when *Spiraea x vanhouttei* blooms. When mines appear, use any listed control in mid–May and again in late–June. Use *Cygon* or *Metasystox–R* after mines appear. Use *Cygon 2E* as a soil drench or "brush–on" treatment.
	Birch skeletonizer *(Bucculatrix canadensisella)*	➤ Sevin 50W, 2.0–3.0 kg	Generally not a problem. Small yellowish–green larvae attack birches and some alders. Feeds on the bottom of leaves from mid– to late–summer. Collect and destroy fallen leaves to remove overwintering pupae. Thoroughly spray underside of leaves about mid–Aug.
	Bronze birch borer *(Agrilus anxium)*	➤ Dursban 2E, 1 L ➤ Pyrate 480EC, 500 mL	Attacks injured and weakened birch trees. The elongated white larvae make long, winding tunnels just under the bark. Tunnels show as spiral ridges around the branches and trunk. **[Plate 10]** Larvae develop over 2 years and emerge as adults from June to Aug., through a D-shaped hole. **[Plate 11]** Adult is a slender, olive–bronze beetle. Remove and destroy weakened and dying branches before mid–May. Good tree health reduces infestation risks. Birch roots don't compete well with lawn grasses. Deeply water the root zone several times during the growing season. Control birch leaf miners to reduce stress. Direct spray at trunk and branches. Chemical control is very difficult.
	Gypsy moth *(Lymantria dispar)*	➤ Dipel 132ES, 1.6–2.4 l/ha ➤ Foray 48B, 1.0–1.6 l/ha ➤ Orthene 75SP, 850 g ➤ Sevin XLR PLUS, 2.3–3.5 l ➤ Thuricide HPC, 1.6 l	Dark, hairy caterpillars with five pairs of blue spots (tubercles) followed by six pairs of red ones along their backs. **[Plate 12]** They feed in the spring and early–summer, reaching about 6 cm long at maturity. They consume foliage of many trees and shrubs, but prefer basswood, birch, hawthorn, oak, poplar, and willow. Females lay eggs in brown fuzzy masses July and Aug. **[Plate 13]** Remove and destroy egg masses before they hatch. Egg masses on the north side hatch later than those on the south side. Apply treatments about 3 weeks after hatching, when *Spiraea x vanhouttei* are in bloom. Treat larvae as feeding begins. A folded burlap cloth wrapped around a tree provides a daytime shelter for larvae or pupae. Collect them from these shelters and destroy them.
	Japanese beetle	➤ See under ROSA	

BUXUS — boxwood

Pest	Control/1000 Litres Water	Remarks
Boxwood leafminers *(Monarthropalpus buxi)*	➤ Cygon 480E, 1 L ➤ DZN 600EW, 830 mL ➤ Diazinon 500EC, 1 L ➤ Lagon 480, 1 L ➤ Malathion 50, 1.5 L ➤ Sevin 50W, 2.0–3.0 kg	The adult is a gnat–like fly. Larvae overwinter in leaves. Leaves are mined during the summer. Treat in June when first mines begin to appear.
Boxwood psyllid *(Psylla buxi)*	➤ Sevin 50W, 2.0–3.0 kg	Young nymphs feed on developing leaves. Leaves become cupped, enclosing the nymphs. Overwintering eggs hatch as buds begin to break in spring. Treat young psyllids in early–May.
Canker	Remove dead branches when noticed. Remove and destroy dead leaves.	

CARYA — hickory

Pest	Control/1000 Litres Water	Remarks
Hickory gall aphid *Phylloxera caryaecaulis*	➤ Dursban 2E, 750 mL ➤ Malathion 500EC, 1.25 L ➤ Pyrate 480EC, 375 mL	Produces nearly round galls on hickory twigs and leaf stems. Galls are about 16 mm in diameter. Girdled twigs die and break at the location of a gall. Overwintering eggs hatch as buds break. Apply controls at that time. Treatment is ineffective once galls appear. Infestations will not kill the tree.
Walnut caterpillar	➤ See under JUGLANS	
Lacebug	➤ See under FRAXINUS	
Leaf spot	➤ See under CATALPA	

CATALPA — catalpa

Pest	Control/1000 Litres Water	Remarks
Leaf spot	Bordeaux mixture	Usually not necessary to spray. Destroy or compost fallen leaves. If severe, spray with Bordeaux mixture 3 times: as leaves unfold, when leaves reach full size, and again 2 weeks later.

CHAENOMELES — quince

Pest	Control/1000 Litres Water	Remarks
Fire blight	➤ See under MALUS	[Plate 33]

CRATAEAGUS — hawthorn

	Pest	**Control/1000 Litres Water**	**Remarks**
INSECTS	Eastern tent caterpillar	➢ See under MALUS ➢ Orthene 75WP, 1.0 kg	**[Plate 31]**
	Gypsy moth	➢ See under BETULA	**[Plate 12 and 13]**
	Hawthorn leafminer *(Profensua collaris)*	➢ Malathion 500EC, 2.5 L ➢ Sevin 50W, 2.0–3.0 kg	Forms a blotch mine covering half or more of each leaf. Foliage of heavily infested trees looks scorched. Adult is a small, black sawfly that emerges from the soil as the first leaves start to emerge and blossoms begin to open. Adults active as leaves begin to unfold. Treat foliage under-surface in late–May and early–June to control larvae.
DISEASES	Leaf blight *(Diplocarpon* sp).	➢ Dithane M–45 80WP, 2.75–3.5 kg	Causes small brown spots on leaves in mid–summer. Spray in spring as leaves emerge. Don't crowd plants—maintain adequate sunlight and good air circulation. Avoid summer pruning, which encourages susceptible soft growth.
	Hawthorn Rust *(Gymnosporangium globosum)* Quince Rust (G. *clavipes)*	➢ Daconil 2787F, 2.5 L	Orange spots on leaf surfaces. Finger–like structures appear on leaf undersides by mid to late summer (*G. globosum)*.**[Plate 14]** Infections of *G. claviceps* also appear on fruit and stems. **[Plate 15]** Apply fungicide before bloom. Remove alternate juniper hosts. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Leaf spot *(Fabraea* sp).	➢ Daconil 2787F, 2.5 L	Slightly depressed, angular, reddish–brown spots which join together. By mid–summer, dead areas have dark raised bumps (fruiting structures). Collect and destroy fallen leaves. Spray as flower buds open. Repeat if spots develop 10 and 20 days later. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Scab	➢ See under *MALUS*	**[Plate 34]**
	Fire blight	➢ See under MALUS	**[Plate 33]**

CORNUS — dogwood

	Pest	**Control/1000 Litres Water**	**Remarks**
DISEASES	Twig blight		Caused by several different fungi. Cankers appear at the base of dead twigs. Prune infected twigs and branches back to healthy wood. Improve cultural conditions by watering during drought and fertilizing. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Leaf spot	➢ Daconil 2787F, 2.5 L	Caused by several different fungi. **[Plate 16]** Avoid overhead irrigation late in the day. Don't crowd plants—maintain adequate sunlight and good air circulation.

EUONYMUS — euonymus

	Pest	**Control/1000 Litres Water**	**Remarks**
INSECTS	Black vine weevil	➢ See under TAXUS	**[Plate 68 & 69]**
	Euonymus scale *(Unaspis euonymi)*	➢ [1]APM 50W, 1.0–1.25 kg ➢ [1]Guthion 240SC, 1.75–2.5 L ➢ [1]Guthion 50WP, 0.925–1.25 kg ➢ [1]Sniper 50W, 0.925–1.25 kg ➢ Cygon 480E, 2 L ➢ Ethion superior oil, 20 L ➢ Orthene 75SP, 1.0 kg ➢ Superior oil, 20 L	This greyish, pear–shaped scale affects bittersweet, *Celastrus*, and pachysandra. **[Plate 17]** It produces 2 generations a year. Examine plants during the dormant season. Spray mid–June as nymphs emerge. *Catalpa speciosa* are beginning to bloom at this time; *Klokwitzia* and *Philadelphus* are blooming. Repeat treatment after 7 days. [1] *Minimum reentry period is 48 hrs.*
	Euonymus webworm (*Yponomeuta cognatella*)	A pale green caterpillar with black spots along each side. Feeds on leaves in localized, webbed colonies. **[Plate 18]** Severe defoliation can occur during June. Monitor deciduous euonymus for webbed colonies in May and June. Where possible, prune colonies out and destroy.	

EUONYMUS — euonymus (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Anthracnose *(Glomerella cingulata)*	➢ Daconil 2787, 2.5 L	Leaf spotting, leaf drop, and twig dieback may occur. To protect new growth, spray at spring bud break—especially on plants in overwintering houses. Don't crowd plants—maintain adequate sunlight and good air circulation. Avoid overhead irrigation late in the day. Prune out dead and dying twigs.
	Crown gall *(Agrobacterium tumefaciens)*	➢ Dygall, 160 g/50 L	Large abnormal growths on stems and roots. Susceptible plants must be treated before disease exposure or final field placement. Don't wound or damage the plants. Remove and destroy infected plants.

FAGUS — beech

	Pest	Control/1000 Litres water	Remarks
INSECTS	Aphid Beech blight aphid *(Fagiphagus imbricator)* Woolly beech leaf aphid *(Phyllaphis fagi)*	➢ *Endosulfan 400, 1.25–1.75 L ➢ *Thiodan 4EC, 1.25–1.75 L ➢ [1]APM 50W, 1.0–1.25 kg ➢ [1]Guthion 50WP, 0.925–1.25 kg ➢ Pyrate 480EC, 375 mL ➢ Dursban 2E, 750 mL ➢ Malathion 500EC, 1.25 L ➢ Orthene 76SP, 1.0 kg ➢ [1]Sniper 50W, 0.925–1.25 kg	Conspicuous white, cottony threads cover beech blight aphid and woolly beech leaf aphid. Beech blight aphid appears on twigs and small branches. The woolly beech leaf aphid feeds on leaf undersides. While unsightly, they cause little tree damage unless very high populations exist. Treat when aphids first appear and repeat as needed. Excessive fertilization or pruning can cause undesirable succulent growth levels. **Endosulfan* and *Thiodan* toxic to fish. [1] *Minimum reentry period is 48 hrs.*
	Cankerworm	➢ See under *MALUS* ➢ Orthene 76SP, 1.0 kg	**[Plate 29 & 30]**
	Gypsy moth	➢ See under *BETULA*	**[Plate 12 & 13]**

FORSYTHIA — forsythia

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Bacterial blight *(Pseudomonas syringae)*	➢ Clean Crop Copper Spray, 6.0 kg	Young shoots or leaves turn black between early–spring and early–summer, especially during wet, cool weather. Apply once in October and again in January. During blight conditions in April and May, apply 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Avoid overhead irrigation late in the day. Don't crowd plants—maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels.

FRAXINUS — ash

	Pest	ControL/1000 Litres Water	Remarks
INSECTS	Ash flower gall mite *(Eriophyses fraxiniflora)*	➢ Ethion superior oil, 20 L ➢ Malathion 25WP, 2.0 kg ➢ Superior oil, 20 L	Becomes active as ash male flower buds break in the spring. Feeds on the unfolding tissues, causing them to form irregular gall clusters of 12 mm diameter. Use *superior oil* or *Ethion superior oil* as a dormant treatment. Mites become active as flower buds break in the spring. Use Malathion when first blossoms begin to form.
	Ash borer *(Podosesia syringae)*	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4EC, 1.25 L ➢ Dursban 2E, 1.0 L ➢ Pyrate 480EC, 500 mL	Adults are dark brown, wasp–like moths, present from late–May to late–July. Larvae bore into trunks near the base. Lilac, mountain ash, and privet are also hosts. Cut and destroy infested wood before May. Stressed trees are more susceptible to borers. Prevent wood and bark damage. Remove badly infested trees. Use pheromone traps. Treat trunk and large branches, especially around wounds. Repeat twice at 10-day intervals. Begin applications about 10 days after peak catch numbers. **Endosulfan* and *Thiodan* toxic to fish.

FRAXINUS — ash (cont'd)

	Pest	**ControL/1000 Litres Water**	**Remarks**
INSECTS	Ash plant bug *(Tropidosteptes amoenus)*	➢ Dylox 420, 2.75–4.0 L ➢ Sevin 80S, 1.25–2.0 kg	Feeds on *Fraxinus americana* and *F. pennsylvanica.* Young nymphs feed on leaf bottoms, causing leaf stippling. To monitor for plant bugs, tap a branch over a sheet of white paper or tapping tray.
	Fall webworm *(Hyphantria cunea)*	➢ Dipel 132ES, 0.7–1.7 L/ha ➢ Dursban 2E, 1.0 L ➢ Orthene 75SP, 1.0 kg	Large webs appear in Aug. over branch ends of ash, box–elder, flowering crab, and many shade trees. **[Plate 19]** The very hairy caterpillar is pale yellowish green. Chemical control rarely needed. Remove webs and caterpillars by hand and destroy.
	Gypsy moth	➢ See under *BETULA*	**[Plate 12 & 13]**
	Lacebug *(Corythucha ciliata)*	➢ [1]APM 50W, 1.0–1.25 kg ➢ [1]Guthion 50WP, 0.925–1.25 kg ➢ [1]Sniper 50W, 0.925–1.25 kg ➢ Malathion 500EC, 1.25 L ➢ Orthene 75SP, 1.0 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	Flat, rectangular insects, 4–6 mm long with broad, transparent, lace–like wing covers. Adults and nymphs feed on underside of leaves. Leaves become pale and mottled, with white splotches. Lower leaf surfaces develop black and brownish dots. Heavily infested leaves may turn entirely brown and fall off. Most species have 2 generations a year. Lacebugs usually occur on a single host. Other trees commonly attacked include elm, hickory, linden, oak, and walnut. Apply to leaf bottoms when insects first appear. [1] *Minimum reentry period is 48 hrs.*
	Oystershell scale *(Lepidosaphes ulmi)*	➢ Diazinon 500EC, 1.5 L ➢ Dursban 2E, 4.0 L ➢ Ethion superior oil, 20 L ➢ Malathion 500EC, 2.5 L ➢ Orthene 75SP, 1.0 kg ➢ Pyrate 480EC, 2 L ➢ Superior oil, 20 L	Attacks over 125 forest, shade, fruit, and ornamental tree species. In heavy infestations, greyish scales completely encrust twigs and stems—this can cause branch and tree mortality. Mature females are 3 mm long and rounded at the rear. Use *superior oil* or *Ethion superior oil* as a dormant treatment. Use any of other materials against crawlers in late–May. Apply again 10 days later, about the time *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches, and leaf bottoms.
DISEASES	Anthracnose *(Gloeosporium aridum)*	➢ Dithane M–45, 80WP, 2.75–3.5 kg ➢ Manzate 200DF, 2.75–3.50	Causes leaf spots, marginal leaf browning and leaf deformation. **[Plate 20]** Defoliation may occur in late–spring and early–summer. Apply at 10–14 day intervals, beginning before bud burst and continuing while wet weather persists in spring. Collect and destroy fallen leaves. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Dieback	➢ See *ABIOTIC DISEASES*	
	Leaf spot, *(Mycosphaerella sp).*	➢ Daconil 2787F, 2.5 L	Brown spots with yellowish borders appear by late–summer. Apply at bud break. Collect and destroy fallen leaves. Don't crowd plants—maintain adequate sunlight and good air circulation.

GLEDITSIA — honey locust

	Pest	**Control/1000 Litres Water**	**Remarks**
INSECTS	Cottony maple scale	➢ See under *ACER*	**[Plate 2]**
	Leafroller	➢ See under *MALUS*	
	Honeylocust mite *(Eotetranychus multidigituli)*	➢ [1]Guthion 50WP, 0.925–1.25 kg ➢ [1]Sniper 50W, 0.925–1.25 kg ➢ Kelthane EC, 1.25–2.50 L ➢ Orthene 75SP, 1.0 kg	Adults overwinter on bark. Feeding causes stippled, bronzing, and discoloured foliage. **[Plate 21]** Heavy infestation may cause defoliation. Treat when mites appear and again in 10 days. Repeat procedure as needed. [1] *Minimum reentry period is 48 hrs.*
	Honeylocust plant bug *(Diaphnocoris chlorionis)*	➢ Dylox 420, 2.75–4.0 L ➢ Sevin 80S, 1.25–2.0 kg	Plant bugs become active as new leaves begin to develop. They cause leaf yellowing, stippling, stunting, and deforming early in the season. Shoot dieback may occur. To monitor for plant bugs, tap a branch over a sheet of paper or tapping tray or use a sweep net.
	Honeylocust podgall midge *(Dasyneura gleditschiae)*	The adult is a small fruit fly–like insect. It lays eggs on new leaflets, and larvae feed on the inner surface. This causes a pod–like structure to appear. There are several generations a year. Chemical control is very difficult.	

GLEDITSIA — honey locust (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Leafhopper *(Macropsis fumipennis)*	➢ [1]APM 50W, 1.0–2.5 kg ➢ [1]Guthion 50WP, 0.925–1.25 kg ➢ [1]Sniper 50W, 0.925–1.25 kg ➢ Dursban 2E, 2.0 L ➢ Methoxychlor 240EC, 4.0 L ➢ Orthene 75SP, 1.0 kg ➢ Pyrate 480EC, 1.0 L ➢ Sevin XLR PLUS, 2.3–3.5 L	Symptoms include leaf spotting and stippling. Leafhoppers become active as new leaves begin to develop. Treat leaf bottoms when leafhoppers are active (about mid–June) and repeat as needed. To monitor leafhoppers, tap a branch over a sheet of paper or tapping tray or use a sweep net. [1] *Minimum reentry period is 48 hrs.*
	Lecanium scale	➢ See under *Fraxinus*	
	Rust mite	➢ Kelthane 187.5EC, 1.25 L	Heavy infestations may cause foliage bronzing. Apply to both leaf surfaces when mites are active (about mid–June) and repeat as needed.
	Thrips	➢ See under *LIGUSTRUM*	

HYDRANGEA — hydrangea

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Botrytis blight	➢ Botran 75W, 1.75 kg	Infected plant parts develop a fuzzy grey growth under very high humidity. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Don't crowd plants—maintain adequate sunlight and good air circulation.

JUGLANS — butternut walnut

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Walnut blister mite *(Aceria erinea)*	➢ Kelthane 187.5EC, 2.5 L	Feeds on walnut and butternut leaves, causing yellow or brown felt–like galls. Overwintering mites become active as new spring growth begins. Apply to lower surface of newly–formed leaves.
	Walnut caterpillar *(Datana integerrima)*	➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 4.0 L ➢ Sevin 50W, 2.0–3.0 kg	Larvae are black with long gray hairs. Feeds on walnut and hickory. Caterpillar colonies descend tree trunks and molt, leaving a conspicuous clump of gray cast skins on the trunk. Adult moths lay eggs in early–July, and larvae feed until the end of Aug. Spray when larvae first appear, usually in July. Feeding will continue into Aug. and Sept. Spray or remove larvae clustering on trunk.
DISEASES	Butternut canker *(Sirococcus clavigignenti–juglandacearum)*	Dark brown–black cankers on branches and/or stems. Cankers are sunken, elongated, and diamond–shaped. Dying branches in the crown. Older cankers may show successive rings of callus loosely covered with bark. During spring, thin black fluid oozes from cracks in the bark and deposits a dried, sooty black stain. No known treatment.	

JUNIPERUS — juniper

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Juniper midge *(Contarinia juniperina)*	➢ Cygon 480E, 2.5 L	A problem on eastern red cedar, *Juniperus virginiana*. Tips of injured plant shoots turn brown during June and July due to midge larvae feeding from the previous summer. No serious damage. Adults active from late–May to July. If needed, treat the foliage at 2–3 week intervals beginning in late–June.
	Juniper scale *(Carulaspis juniperi)*	➢ DZN 600EW, 1.25 L ➢ Diazinon 500EC, 1.5 L ➢ Malathion 500EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L	A small, circular, white scale with a yellow centre. **[Plate 22]** Turns juniper and arborvitae needles yellow. Attacks all juniper species, including Pfitzer and Savin. Sooty mould fungus sometimes develops. Treat crawlers about late–June and repeat as needed, starting when *Philadelphus* is at full bloom and *Catalpa* are beginning to bloom. Don't use *Malathion* on Savin or Canaetri junipers.

JUNIPERUS — juniper (cont'd)

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Juniper tip gall midge *(Rhopalicus sp).*	Galls on shoot ends caused by larvae feeding. The adult is a chalcid wasp.	
	Juniper webworm *(Dichomeris marginella)*	➢ Cygon 480E, 2.5 L ➢ Lagon 480, 2.5 L ➢ Sevin 50W, 2.0–3.0 kg	A light brown caterpillar, about 12 mm long, that feeds at the base of needles. Needles are webbed together during early–fall and again the following spring. Treat foliage when larvae are active (late–Aug. and Sept.).
	Spruce spider mite	➢ Morsetan 0.625–1.25 kg ➢ See under PICEA	
	Tarnish plant bug	➢ See under THUJA	**[Plate 74]**
DISEASES	Cedar–apple rust *(Gymnosporangium juniperi–virginianae)* Hawthorn rust *(G. globosum)* Quince rust *(G. calvipes)*	Cedar–apple and hawthorn rust cause galls on juniper twigs. When dormant, cedar-apple rust galls **[Plate 23]** and hawthorn rust galls **[Plate 24]** can be located in juniper foliage by their orange horns. Quince rust causes cankers in the twigs. In April, prune out galls and cankers on infected branches. Separate as far as possible from Rosaceous rust hosts. Plant resistant junipers. Don't crowd plants—maintain adequate sunlight and good air circulation.	
	Blight (dieback) *(Phomopsis juniperovora)* or *(Kabatina juniperi)*	➢ Copper Spray, 4.0 kg ➢ Dithane M–45, 80WP, 2.75–3.5 kg	Causes dieback of new shoots. **[Plate 25]** Stressed plants and wounded shoots are more susceptible. Avoid overhead irrigation late in the day. Don't crowd plants—maintain adequate sunlight and good air circulation. If possible, prune out infected areas. Maintain healthy growth, but don't encourage soft, succulent growth through excessive pruning and over fertilization. Spray when spring growth starts. Repeat at 10 day intervals until growth stops. Laboratory diagnosis is needed to distinguish between *Kabatina* and *Phomopsis.*

LARIX — larch

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Larch casebearer *(Coleophora laricella)*	➢ Malathion 500EC, 2.5 L	Larvae feed in needles until late–summer. Mined needles make the tree appear frost damaged. Treat in early–May.
	Larch sawfly *(Pristiphora erichsonii)*	➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 4.0 L ➢ Orthene 75SP, 1.0 kg ➢ Sevin 50W, 2.0–3.0 kg ➢ Sevin 80S, 1.25–2.0 kg	Larvae are grey with black heads, 20 mm long. Active mid– to late–summer. Monitor for shepherd's crooks, caused by egg laying, in the new growth. Treat foliage in July when larvae are half–grown.
	Tarnish plant bug	➢ See under THUJA	
	Woolly larch adelgid *(Adelges lariciatus)*	➢ Malathion 500EC, 1.25 L	Adelgids feed on needles and are covered by waxy, wooly, cottony threads. Heavy infestations look like snow. Damaged leaves become bent or twisted. Treat foliage thoroughly when aphids first appear (about early–May).

LIGUSTRUM — privet

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Lilac leafminer	➢ See under SYRINGA	Treat both leaf surfaces when mites first appear in late–May. Repeat as required.
	Privet rust mite *(Aculus ligustri)*	➢ Kelthane 187.5EC, 2.5 L	Mites become active as new leaves emerge, from May to November. Damage appears as leaf russeting. Treat when mites first appear. Repeat as needed. Encouraged by cooler weather.
	Privet Thrips *(Dendrothrips ornatus)*	➢ [1]Guthion 50WP, 0.925–1.25 kg ➢ [1]Sniper 50W, 0.925–1.25 kg ➢ Dursban 2E, 1.0 L ➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 4.0 L ➢ Orthene 75SP, 1.0 kg ➢ Pyrate 480 EC, 500 mL ➢ Sevin XLR PLUS, 2.3–3.5 L	Treat at first sign of infestation and repeat as needed. Injury appears as yellowish flecks on leaves. Leaves look greyish or dusty. [1] *Minimum reentry period is 48 hrs.*

LIGUSTRUM — privet (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Anthracnose and twig blight *(Glomerella sp.)*	➢ No chemical control	Leaves turn brown and remain attached to twigs. Prune and destroy infected branches during dry weather. *Ligustrum amurense, L. x ibolium*, and *L. obtusifolium regelianum* do not appear susceptible.
	Leaf spot Several fungi	➢ Daconil 2787F, 2.5 L	Brown spots appear on leaves, especially after wet springs. Treat plants during prolonged wet conditions. Don't crowd plants—maintain adequate sunlight and good air circulation.

LIRIODENDRON — tuliptree

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Tuliptree aphid *(Macrospiphum liriodendri)*	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4EC, 1.25–1.75 L ➢ Malathion 500EC, 1.25 L	A green aphid found on underside of leaves from late–June to late–Sept. Treat when aphids first appear and repeat as needed. Excessive fertilization or pruning can cause excessive, susceptible succulent growth. **Endosulfan* and *Thiodan* toxic to fish.
	Tuliptree scale *(Toumeyella liriodendri)*	➢ Malathion 500EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	Dark brown, hemispherical scale attacks several deciduous tree species. Use *superior oil* as a dormant treatment in early–spring. Use any 1 of other materials when crawlers appear in Aug.

LONICERA — honeysuckle

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Honeysuckle aphid *(Hyadaphis tataricae)*	➢ Malathion 500EC, 1.25 L ➢ Pirimor 50WP, 500 g	Causes early season curling and dwarfing of terminal shoots. Affected branch portion may be several cm long. Affected stems eventually die, causing a witches' broom. May completely disfigure heavily affected bushes. Dead shoots visible the following spring. Prune out witches' brooms from the previous season before buds begin to break in the spring. Apply dormant oils after pruning to control overwintering eggs. Apply treatment when buds begin to break. Repeat at least once after a 3–week interval. Susceptible varieties include: *Lonicera x bella* 'Dropmore,' *L. korolkowii* 'Zabelli,' *L. tatarica* 'Grandiflora,' 'Rosea,' 'Hack's Red,' and 'Red Giant.'
DISEASE	Honeysuckle Blight (*Herpobasidium deformans)*	➢ Dithane DG 2 kg	Not a common disease in most of Ontario. Many species are susceptible. Symptoms appear as new leaves exapnd in spring. Infected leaves are curled and turn brown. The veins tend to remain green at first. Spray chemical when leaf buds show green tip to half inch green leaf. Repeat application in 10–14 day intervals. Avoid overhead irrigation late in the day. Remove and destroy infected leaf material to reduce inoculum the following spray.

MAGNOLIA — magnolia

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Magnolia scale *(Neolecanium cornuparvum)*	➢ Dursban 2E, 4 L ➢ Malathion 500EC, 2.5 L ➢ Orthene 75WP, 1.75 kg ➢ Sevin XLR PLUS, 2.3–3.5 L ➢ Superior oil, 20 L	Mature scale is pale yellow–green. Causes smaller leaves, sooty mold, and twig dieback on *Magnolia acuminata, M. x soulangiana*, and *M. stellata*. Nymphs of this large scale are purple in mid–summer, turning white by late–summer. **[Plate 27** Overwinter as tiny nymphs on this year's wood. **[Plate 26]**

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4EC, 1.25 L ➢ Cygon 480E, 1.25 L ➢ Lagon 480, 1.25 L ➢ Malathion 500EC, 1.25 L ➢ [1]Sniper 50W, 0.625–0.775 kg	Treat when adults first appear and repeat as required. **[Plate 28]** ******Endosulfan* and *Thiodan* toxic to fish. [1] *Minimum reentry period is 48 hrs.*
	Fall cankerworm *(Alsophila pometaria)* Spring cankerworm *(Paleacrita vernata)*	➢ Dipel 132ES, 0.5–1.7 L/ha ➢ Foray 48B, 1.0–1.6 L/ha ➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 4.0 L ➢ Sevin 50W, 2.0–3.00 kg ➢ Thuricide, 1.5–2.0 L	Cankerworms are greenish–to–black loopers (inch worms) that appear early in the season and feed on leaves of many deciduous hosts. **[Plate 29 & 30]** Place sticky bands around tree trunks, close to the ground, in the spring and fall. This traps adult females as they emerge from the ground and crawl up the tree trunk. Treat when larvae appear in mid–May, when *Acer platanoides* and *Magnolia x soulangiana* are blooming.
	Eastern tent caterpillar *(Malacosoma americanum)*	➢ Ambush 500EC, 70 mL ➢ Diazinon 500EC, 925 mL ➢ Dipel 132ES, 0.5–1.0 L/ha ➢ Foray 48B, 1.0 – 1.6 L/ha ➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 4.0 L ➢ Pounce, 90 mL ➢ Sevin 50W, 2.0–3.0 kg ➢ Thuricide, 1.5–2.0 L	This caterpillar has 1 yellow stripe down its back. **[Plate 31]** Colonies feed early in the season. Silken tents appear in the forks of branches, mainly of apple, cherry, and hawthorn trees. Prune and destroy overwintering egg masses. These are silver in colour, about 1–2 cm long in a raised band circling a twig. They hatch when buds break in spring. Treat then or at the first sign of webs. In light infestations, remove and destroy the tents (which contain larvae).
	Gypsy moth	➢ See under BETULA	**[Plate 12 & 13]**
	Japanese beetle	➢ See under *ROSA*	**[Plate 62 & 63]**
	Leafrollers: Fruit tree leafroller *(Archips argyrospilus)* Redbanded leafroller *(Argyrotaenia velutinana)*	➢ Methoxychlor 240EC, 4.0 L ➢ [1]Guthion 240EC, 4.0 L ➢ [1]Guthion 50WP, 0.625–0.775 kg ➢ [1]APM 50W, 1.0–1.25 kg ➢ [1]Sniper 50W, 0.625–0.775 kg	Leafrollers are caterpillars that feed while hidden in folded or rolled leaves. Fruit tree and redbanded leafrollers primarily affect fruit trees, but also attack many shade trees and ornamentals. Apply to foliage soon after leaves unfold in early–June. [1] *Mimimum reentry period is 48 hrs.*
	Leafhopper (Several species)	➢ [1]Guthion 240SC, 1.75–2.5 L ➢ [1]Guthion 50WP, 0.625–0.775 kg ➢ [1]APM 50W, 1.0–1.25 kg ➢ Imidan 50WP, 1.25 kg ➢ Sevin 50W, 2.0 kg ➢ Methoxychlor 240EC, 4.0 L ➢ [1]Sniper 50W, 0.625–0.775 kg	Check regularly for infestation when cutting alfalfa or hay. Injury appears as yellowish flecks on the leaf surface. **[Plate 32]** Hang yellow sticky traps in the canopy to monitor for leafhoppers. Check by disturbing plants or looking at the leaf bottoms for leafhopper nymphs or molted skins. Treat as required. [1] *Minimum reentry period is 48 hrs.*
	Oystershell scale *(Lepidosaphes ulmi)*	➢ Superior oil, 20 L ➢ Ethion superior oil, 20 L ➢ Diazinon 500EC, 1.25 L ➢ Malathion 500EC, 2.5 L	Attacks over 125 species of forest, shade, fruit, and ornamental trees. In heavy infestations, greyish scales completely encrust twigs and stems and can kill branches and trees. Mature females are 3 mm long and rounded in the rear. Use *superior oil* or *Ethion superior oil* as a dormant treatment. Use any of other materials against crawlers in late–May. Repeat in 10 days, when *Spiraea x vanhouttei* is blooming. Ensure good coverage of trunk, branches, and leaf bottoms.
	Mites: European red mite *(Panonychus ulmi)* Two spotted spider mite *(Tetranychus urticae)*	➢ Superior oil, 20 L ➢ Ethion superior oil, 20 L ➢ Vendex 50W, 0.5–1.0 kg	Apply oil when plants show ½ inch of green tissue and to flower buds showing as a tight cluster. This can improve control of European red mite. Two spotted spider mite does not overwinter on the plant and is not controlled by the oil treatment.

MALUS — apple (cont'd)

Pest	Control/1000 Litres Water	Remarks
Cedar–apple rust *(Gymnosporangium juniperi–virginianae)*	➤ Daconil 2787F, 2.5 L ➤ Ferbam 76WDG, 1.25–2.25 kg ➤ Polyram 80DF, 2.0 kg ➤ Zineb 80WP, 1.25 kg	Causes orange spots on leaf surface and finger–like structures on underside of leaves by mid– to late– summer. Remove alternate juniper hosts. Don't crowd plants—maintain adequate sunlight and good air circulation. Apply twice to foliage about May 10 and May 20, at spring bud break.
Fire blight *(Erwinia amylovora)*	➤ Agri–Mycin 17, 100 ppm ➤ Bordeaux mixture, 3–5–1000 ➤ Copper Spray, 1.25 kg	Dead, dry leaves persist on infected branch. **[Plate 33]** Spray at early bloom, full bloom, and petal fall where fire blight is a recurring problem. Fire blight affects succulent vegetative growth—avoid excessive pruning and nitrogen fertilization in spring. During dormancy, prune out infected branches about 30 cm below the cankered area when the tree is dry. Some cultivars are resistant.
Apple scab *(Venturia inequalis)*	➤ Benlate 50WP, 550g +Mancozeb 80WP, 3.25 kg ➤ Captan 50WP, 2.0 kg ➤ Captan 80WDG, 1.25 kg ➤ Cyprex 65WP, 500 g ➤ Daconil 2787F, 2.5 L ➤ Polyram 80DF, 2.0 kg	Infection causes lesions on leaves and fruit. **[Plate 34]** Start fungicide applications when leaf buds begin to break. Repeat every 7–10 days during May and June, especially in rainy weather. If no infection exists by the end of June, stop fungicide treatment. Clean up and destroy fallen leaves. Prune to improve air circulation through the canopy. Plant resistant cultivars.

PACHYSANDRA — pachysandra

Pest	Control/1000 Litres Water	Remarks
Euonymus scale	➤ See EUONYMUS	**[Plate 17]**

PICEA — spruce

Pest	Control/1000 Litres Water	Remarks
Cooley spruce gall adelgid *(Adelges cooleyi)*	➤ *Endosulfan 400, 1.25 L ➤ *Thiodan 4EC, 1.25–1.75 L ➤ Dursban 2E, 750 mL ➤ Malathion 500EC, 1.25 L ➤ Pyrate 480EC, 375 mL ➤ Sevin 50W, 2.0–3.0 kg	Long, plump galls form on the current year's shoots of Colorado blue spruce, Engelmann spruce, and Sitka spruce. **[Plate 35]** Douglas fir is an alternate host **[Plate 36]**. Causes needles to twist and turn yellow, but does not form a gall. Treat in early–spring before bud break or in early–October. Thoroughly cover crevices in the bark of terminal twigs and the bases of buds. On blue spruce, use only wettable powders to prevent foliage discoloration. If possible, remove and destroy galls in June. **Endosulfan* and *Thiodan* toxic to fish.
Eastern spruce gall adelgid *(Adelges abietis)*	➤ *Endosulfan 400, 1.25 L ➤ *Thiodan 4EC, 1.25–1.75 L ➤ Dursban 2E, 750 mL ➤ Ethion superior oil, 20 L ➤ Malathion 500EC, 1.25 L ➤ Sevin XLR PLUS, 2.3–3.5 L ➤ Superior oil, 20 L	Pineapple–shaped galls form at the base of current year shoots on Norway, white, red, and black spruce. **[Plate 37]** Old galls remain attached for long periods, turning black and making the tree look scraggly. With light infestations, remove and destroy galls before midsummer. Use *superior oil* or *Ethion superior oil* as a dormant treatment. Use any of the other materials when aphids migrate to new shoots in mid–May. On blue spruce, use only wettable powders to prevent foliage discoloration and avoid *superior oil* and *Ethion superior oil.* **Endosulfan* and *Thiodan* toxic to fish.
Pine needle scale	➤ See under PINUS	**[Plate 45 & 46]**

	Pest	**Control/1000 Litres Water**	**Remarks**
INSECTS	Spruce budworm *(Choristoneura fumiferana)*	➢ Ambush 500EC, 35–70 mL ➢ Cygon 480E, 1.25 L ➢ Dipel 132ES, 1.2–2.4 L/ha ➢ Foray 48B, 1.6–2.4 L/ha ➢ Lagon 480, 1.25 L ➢ Lannate L, 1.25–1.75 L ➢ Malathion 500EC, 2.5 L ➢ Sumithion 50EC, 0.35–0.56 L	A widespread and important defoliator of balsam fir and spruce. Begins to feed as buds break and continues until mid– to late–June. Seldom a problem on landscape trees. Larva has a black head and brownish body with 4 light spots on the back of each segment. **[Plate 1]** One generation per year. In mid–May, apply general coverage spray to control larvae. In balsam fir, overwintering larvae become active about 2 weeks before bud break. Apply general coverage spray to control larvae from mid–May to mid–June.
	Spruce bud scale *(Physokermes piceae)*	➢ Ethion superior oil, 20 L ➢ Malathion 500EC, 2.5 L ➢ Superior oil, 20 L	A globular, mahogany–brown scale that clusters on spruce. Lower branches become ragged, with some die–back. Monitor for honeydew and sooty mold. Spray to control the crawlers in mid–July. Repeat 10 days later.
	Spruce spider mite *(Oligonychus ununguis)*	➢ Cygon 480E, 1.25 L ➢ Dursban 2E, 750–1000 mL ➢ Lagon 480, 1.25 L ➢ Malathion 500EC, 1.25 L ➢ Orthene 75SP, 1.0 kg ➢ Pentac Aquaflow, 400 mL ➢ Pyrate 480EC, 375–500 mL ➢ Superior oil, 20 L ➢ Vendex 50W, 0.5–1.0 kg	Overwintering eggs hatch in late–April and early–May, when *Amelanchier* and *Acer platanoides* bloom. Young nymphs can be controlled by chemicals. Pests prefer older needles as feeding sites. **[Plate 38]** Many predacious mites control populations. Use *superior oil* as a dormant treatment in early–spring. On blue spruce, use only wettable powders to prevent foliage discoloration and avoid *superior oil* and *Ethion superior oil*. Then apply 2 sprays of other materials at 10-day intervals when mites exist in summer. Use miticides alone for maximum effectiveness. To monitor for mites, shake a branch over a white sheet of paper and look for crawling mites.
	Spruce needleminer *(Taniva albolineana)*	➢ Malathion 500EC, 2.5 L ➢ Orthene 75SP, 1.0 kg	Larvae bore into the bases of old needles. Young larvae feed in groups, while older larvae feed alone. Builds unsightly nests of dead needles and frass, held together by fine silk strands. **[Plate 39]** Small grey moths appear throughout infested plants in late–May and June. Apply control to foliage about mid–June and repeat in late–June. In fall, or in spring before buds swell, dislodge nests with a strong water stream.
	Strawberry root weevil *(Otiorhynchus ovatus)*	➢ Ambush 500EC, 500 mL	Larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish brown flightless adult is under 6 mm long, and resembles the black vine weevil. Hides during the day and feeds at night. These pests have a large host range. Commonly injured plants include white cedar, spruce, and juniper. Adults are active in late–June and early–July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing or girdling the current season's shoots while feeding. Infested plants grow slowly or fail to grow and look dry and off–colour. Transplants often die without becoming established. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. *Ambush* is registered for use on seedlings. Treat some conifer seedlings, especially pine, before treating larger area to test treatment safety.
	Tarnish plant bug	➢ See under THUJA	**[Plate 74]**
	White pine weevil	➢ See under PINUS	**[Plate 55 & 56]**
DISEASES	Botrytis	➢ See under THUJA	Seedlings
	Canker Branch Dieback *(Cytospora Valsa)*	Kills individual, scattered lower branches. **[Plate 40]** First symptoms are browning and needle loss. Norway and Colorado spruce are very susceptible. Prune out diseased branches and twigs when bark is dry. Maintain good growing conditions. Avoid damaging trunk and branches.	

PICEA — spruce (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Needlecast *(Rhizosphaera kalkhoffii)*	➤ Copper Spray, 4.0 kg ➤ Daconil 2787F, 9.5 L	Often becomes apparent between early–spring and early–summer when needles infected the previous season turn purple or lavender. **[Plate 41]** By mid–season, infected needles drop leaving only current season growth. Colorado blue spruce is very susceptible. Apply first treatment in spring when new growth is 1–2 cm long. Repeat at 3–4 week intervals. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Tip blight *(Sirococcus conigenus)*	➤ Copper Spray, 4.0 kg ➤ Daconil 2787F, 3.6–6 L	Apply first treatment in spring when new growth is 1–2 cm long. Repeat at 3–4 week intervals. Don't crowd plants—maintain adequate sunlight and good air circulation.

PINUS — pine

	Pest	Control/1000 Litres Water	Remarks
INSECTS	European pine shoot moth *(Rhyacionia buoliana)*	➤ [1]Guthion 50WP, 0.85–1.75 kg ➤ Cygon 480E, 2.5 L ➤ Diazinon 500EC, 1.5 L ➤ DZN 600EW, 1.25 L ➤ Sevin 50W, 2.0–3.0 kg ➤ [1]Sniper 50W, 0.85–1.75 kg	Brown larvae with black heads feed on growing shoots in spring. **[Plate 42]** This causes "hooking" of new candles. Adult is a small, orange–flecked moth, usually active in late–June to early–July. Egg hatch coincides with the bloomin of *Catalpa speciosa*. One generation per year. In late–April, apply spray to area between buds on terminals and laterals. Do this when *Acer rubrum* and *Cornus mas* are blooming. Spray terminals about July 10 to prevent injury the following year. If you delay shearing to mid–July, many eggs will be destroyed. Pheromone traps can be used to monitor for adult activity. [1] *Minimum reentry period is 48 hrs.*
	Gypsy moth	➤ See under *BETULA*	
	Northern pine weevil *(Issoides approximatus)*	➤ Methoxychlor ➤ Sevin 50 W, 2.0–3.0 kg	Can be a problem on all pines, especially in Christmas tree production. Often found on *Pinus sylvestris*. Damage includes flagging and browning of new shoots and seedlings. May cause small circular wounds at the base of the damage that exude pitch resin. Remove freshly cut stumps and recently dead and dying trees by late–spring to eliminate adult breeding grounds. Stressed trees are most susceptible. To control adults, treat tender bark of seedlings and young shoots of larger trees in April or late–Aug.
	Pales weevil *(Hylobius pales)*	➤ Methoxychlor ➤ Sevin 50W, 2.0–3.0 kg	A small, brownish weevil that feeds on tender pine twig bark, causing the terminals to turn brown and die. **[Plate 43]** A problem in Christmas tree production. White, legless larvae have brown heads. Larvae feed in long underground tunnels along the wood grain and on the outside of major roots. Remove freshly cut stumps and recently dead and dying trees by late–spring to eliminate adult breeding grounds. Stressed trees are most susceptible. To control adults, treat tender bark of seedlings and young shoots of larger trees in April or late–Aug.
	Pine bark adelgid *(Pineus strobi)*	➤ Dursban 2E, 750 mL ➤ Ethion superior oil, 20 L ➤ Malathion 500EC, 1.25 L ➤ Orthene 75SP, 1.0 kg ➤ Superior oil, 20 L	Mainly affects white pine, though other pines can be infested. Causes white, wooly masses on trunks, stems, and branches. **[Plate 44]** In early–spring, use *superior oil* or *Ethion superior oil* on trunk and branch bark as a dormant treatment. Don't apply oil to white pine. Apply other materials to active nymphs in late–May. Repeat application in 2–3 weeks. Ensure good coverage.

Pest	Control/1000 Litres Water	Remarks
Pine needle scale *(Chionaspis pinifoliae)*	➤ Cygon 480E, 1.25 L ➤ DZN 600EW, 1.25 L ➤ Ethion superior oil, 20 L ➤ Lagon 480, 1.25 L ➤ Malathion 500EC, 2.5 L ➤ Orthene 75SP, 1.0 kg ➤ Superior oil, 20 L	Reddish crawlers appear in late–May, then turn yellowish. **[Plate 46]** Causes whitish spots on pine and spruce needles. **[Plate 45]** Two generations per year. Infestations often start on lower branches. Prune out small infestations in late–winter and early–spring. Use a *superior oil* or *Ethion superior oil* as an early–spring dormant treatment. Don't apply oil to white pine. Crawlers are active when *Syringa vulgaris* and *Spiraea x vanhouttei* are blooming in late–May. Treat at that time and again about 10 days later.
Pine pitch mass borer *(Vespamima pini)*		White and pink larvae affect established pines in the landscape. **[Plate 48]** Large pitch resin masses appear on trunks. **[Plate 47]** Has a 2–3 year life cycle. Stressed and wounded plants are most susceptible. Maintain good tree health—no registered chemical controls exist. Larvae and pupae are found under the pitch masses in May and June. They can be picked off and killed. Remove severely infested trees.
Pine root collar weevil *(Hylobius radicis)*		Feeds on all pines, with Scots and Austrian being most susceptible. Problem areas often appear in isolated pockets or on sandy soils. The white, legless, grub–like larvae feed at the root collar. This causes the trunk to swell. Pitch resin masses mixed with soil also appear. Prune off bottom branches. Pull away fallen needles and other organic matter to expose a circular soil surface 30 cm from the trunk. This increases light and temperature at the tree base, discouraging adult weevils. In mid–June, treat bark at trunk base and the soil surface 20 cm out from the trunk. This controls adults and developing larvae.
Pine sawflies: European pine sawfly *(Neodiprion sertifer)* Redheaded pine sawfly *(Neodiprion lecontei)*	➤ Ambush 500EC, 35–70 mL ➤ Cygon 480E, 1.25 L ➤ Dursban 2E, 1.0 L ➤ Lagon 480, 1.25 L ➤ Malathion 500EC, 2.5 L ➤ Methoxychlor 240EC, 4.0 L ➤ Orthene 75SP, 1.0 g ➤ Pyrate 480EC, 500 mL ➤ Sevin XLR PLUS, 2.3–3.5 L ➤ Sumithion 50EC, 0.56 L or 0.35 L twice	European pine sawfly has a dark–greenish body with dark longitudinal stripes and a black head. **[Plate 49]** It appears in late–May–June. Redheaded pine sawfly has a yellow body with six rows of black spots and a reddish head. **[Plate 50]** It feeds on older foliage in July and Aug. Multiple generations can be present at one time and will attack all foliage. Initial feeding begins in small, easily removed colonies. Spot–treat foliage when you first observe small larvae feeding. Apply *Sumithion* at this time and repeat in 4–6 days.
Pine shoot beetle *(Tomicus piniperda)*		This introduced bark beetle was found in Ohio in 1992 and in Ontario in 1993. By 1994, it was declared a quarantinable pest by *Agriculture* and *Agri–Food Canada*. Pines from many areas of the province are subject to quarantine. The primary host is Scots pine, *Pinus sylvestris*. The 3 mm long adult beetles tunnel within the current season's growth **[Plate 54]**, causing flagging and dropping of shoots. **[Plate 53]** Adult beetles overwinter at the base of trees (30 cm), just inside the outer bark. The adults start to emerge in February-March, when temperatures reach 10°C. They bore into bark to lay their eggs, causing sap to flow out of these wounds. **[Plate 51]** The larvae form galleries in the bark thereby destroying the cambium and weakening/killing the tree. **[Plate 52]** Maintain plant health—no registered chemical controls exist. Don't plant nursery pines and Christmas trees near abandoned pine plantations. To discourage egg laying, remove stumps, pine debris, dying trees, and pruned limbs from the area by Feb.1. Place out uninfested "trap logs" (diameter greater than 6 cm) out to attract mating adults, and destroy them by May 31. Contact the Canadian Food Inspection Agency for the Pest Alert Factsheet on PSB.
Pine spittlebug *(Aphrophora cribrata)*	➤ Dursban 2E, 175–300 mL ➤ Malathion 500EC, 2.5 L ➤ Methoxychlor 240EC, 4.0 L ➤ Pyrate 480EC, 88–150 mL ➤ Sevin 50W, 2.0–3.0 kg	Several different pines are susceptible hosts, with Scots pine often heavily infested. Young nymphs feed on sap from new growth and cover themselves with white, foam–like spittle. Several nymphs may be found in 1 spittle mass. This pest rarely causes serious damage. Treat when spittle masses first appear in mid—late–May.
Pine tortoise scale *(Toumeyella numismaticum)*	➤ DZN 600 EW, 1.25 L ➤ Ethion superior oil, 20 L ➤ Malathion 500EC, 2.5 L ➤ Sevin XLR PLUS, 2.3–3.5 L ➤ Superior oil, 20 L	This reddish—brown oval, convex scale, about 6 mm long, infests several kinds of pine. It removes plant sap and secretes large amounts of honeydew. Remove heavily infested limbs and trees in late–winter and early–spring. In late–June, treat twigs to control nymphs. There are several natural predators.

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Pine webworm *(Tetralopha robustella)*	➤ Methoxychlor 240EC, 4.0 L	A yellowish–brown larva with 2 dark longitudinal stripes on each side. In midsummer, larval colonies feed on needles. These are enclosed in coarse–webbed frass masses on twigs and branches. Apply spray under sufficient pressure to penetrate the webbing. In light infestations, hand–pick or prune infested tips.
	Spruce spider mite	➤ See under *PICEA*	Don't apply oil on white pine.
	Strawberry root weevil	➤ See under *PICEA*	
	Tarnish plant bug	➤ See under *THUJA*	**[Plate 74]**
	White pine aphid *(Cinara strobi)*	➤ Cygon 480E, 2.0 L ➤ Dursban 2E, 750 mL ➤ Lagon 480, 2.0 L ➤ Malathion 500EC, 2.5 L ➤ Orthene 75SP, 1.0 kg ➤ Pyrate 480EC, 375 mL	Aphids often cluster together on shoots. Look for honeydew and sooty mold on needles. Treat active stages in May.
	White pine weevil *(Pissodes strobi)*	➤ Methoxychlor 240EC, 4.0 L	A small, brownish snout beetle that attacks only vertical terminals on pines and spruce. **[Plate 55]** It kills at least 2 years growth. Attacks cause crooked, forked, or multiple–stemmed trees. Legless, white larvae are found in the terminal shoots. **[Plate 56]** In April, spray the vertical terminals. Remove and destroy infested, flagging leaders in June and July.
	Zimmerman pine moth *(Dioryctria zimmermani)*	➤ Cygon 480E, 2 L ➤ Lagon 480, 2.0 L	Grey–green larvae cause pitch resin to collect on pine trunks. Pitch masses appear at the branch whorls, on the trunk, or on shoots near terminal branches. Individual branches may die back completely. Remove larvae from pitch masses in June and July. Prune damaged shoots and remove heavily infested trees. Chemical control is difficult. Spray bark thoroughly in late–April to early–May when overwintering larvae are breaking dormancy (when *Acer platanoides* is blooming). Treat again in mid–Aug. when larvae hatch. Use pheromone traps to monitor adult activity.
DISEASES	Canker *(Scleroderris abietina)*	➤ Daconil 2787F, 2.4–4.8 L	Affects many pines, especially Scots and red pine. Trees under 2½ m are most susceptible. Symptoms appear in spring after infection. Bases of infected needles turn reddish brown by May or June. Needles may be bent. Cool moist weather encourages infection. To reduce spread, prune out lower branches of pine windbreaks around nurseries. Apply treatment in spring when new growth reaches 1–5 cm. Repeat at 3–4 week intervals.
	Diplodia tip blight *(Sphaeropsis sapinea)* *(Diplodia pinea)*	➤ Copper Spray, 4.0 kg	New shoots don't elongate in spring and are stunted by June. **[Plate 57]** Maintain tree health, since infection is hard to control. Apply fungicides at bud break—maximum 3 applications/yr. at 2–week intervals. Removing infected branches does not reduce infection, since spores are also produced on seed cones. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Lophodermium needlecast *(Lophodermium seditiosum)*	➤ Copper Spray, 4.0 kg ➤ Daconil 2787F, 2.4–4.8 L ➤ Dithane M–45, 80WP, 2.5 kg	Previous season's needles turn red in late–winter and early–spring. **[Plate 58]** Infected needles drop from late–spring to early–summer. Black football–shaped fruiting bodies appear on cast needles in mid–summer. Severely defoliates pines, especially Scots and Austrian pine. Only current season's needles remain on the tree over winter. Apply treatment in mid–July to early–Aug., before infection occurs. Repeat at 3–4 week intervals as required. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Tip blight *(Sirococcus)*	➤ Copper Spray, 4.0 kg ➤ Daconil 2787F, 3.6–6 L	Apply treatment in spring when new growth is 1–2 cm long. Repeat at 3–4 week intervals. Don't crowd plants—maintain adequate sunlight and good air circulation.

PINUS — pine (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Brown spot *(Scirrhia)*	➢ Daconil 2787F, 9.5 L	Apply treatment in spring when new growth is 1–2 cm long. Repeat at 3–4 week intervals. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Sweetfern blister rust *(Cronartium comptoniae)*		Affects hard 2– and 3–needle pines, especially jack pine, *Pinus banksiana*. Can cause serious losses in nurseries and young plantations. Cankers often appear below 2½ m on the trunk. Trees with 8 cm basal diameters seem resistant. Destroy diseased pines. Eliminate alternate hosts, *Comptonia peregrina*, sweet fern, and *Myrica gale*, sweet gale, from plantations and from the immediate vicinity of pine nursery stock.
	White pine blister rust *(Cronartium ribicola)*		A serious disease of 5–needle pines, especially native white pine, *Pinus strobus*. Infects the needles, eventually causing a perennial canker on branches and stems. **[Plate 59]** Can also cause an insignificant leaf spot. Prune out girdled pine branches before the canker reaches the main stem. Prune infected, flagging branches 30 cm below the cankered area. Separate white pine nurseries and plantations from alternate host *Ribes sp.* by 600 m.

PLATANUS — London plane, Sycamore

	Pest	Control/1000 L Water	Remarks
DISEASES	Anthracnose *(Apiogominia veneta)*	➢ Daconil 2787F, 2.5 L ➢ Mancozeb 80WP, 2.7 kg	As with frost damage, new leaves turn black–brown. Light brown dead areas appear along veins of mature leaves. Twigs 20–25 cm long may show signs of dieback. Treat up to 3 times, especially in cool, wet weather: as buds swell, at bud break, and about 7 days later. Prune out and destroy cankered twigs and branches. Collect and remove fallen, infected leaves. Don't crowd plants—maintain adequate sunlight and good air circulation.

POPULUS — poplar

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Forest tent caterpillar	See under *ACER*	
	Poplar and willow borer *(Cryptorynchus lapathi)*	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4EC, 1.25 L ➢ Dursban 2E, 1.0 L ➢ Pyrate 480EC, 500 mL	A stout, black, rough–bodied snout beetle with pink outer wing covers. White, legless larvae honeycomb the trunks and larger branches of willows and poplars. Cut and destroy badly infected branches and trees before the end of June. Treat trunk and branch bark in mid–Aug. and Sept. **Endosulfan* and *Thiodan* toxic to fish.
	Gypsy moth	➢ See under *BETULA*	
DISEASES	Canker (Several different fungi)		Most poplar species are susceptible, especially when stressed. Prune out and destroy infected branches during dry weather. Remove and destroy severely infected trees. Don't wound or injure trees. Don'tDon't crowd plants—maintain adequate sunlight and good air circulation.
	Leaf spot (Several fungi)	➢ Daconil 2787F, 2.5 L	Brown spots appear on leaves, followed by defoliation. Collect and remove fallen infected leaves. Treat at bud break, then twice more at 10–14 day intervals.

PRUNUS — black cherry, chokecherry, flowering cherry, pin cherry, peach, plum

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ *Endosulfan 400, 1.25–1.75 L ➢ *Thiodan 4C, 1.25–1.75 L ➢ [1]Sniper 50W, 0.925–1.25 kg ➢ Dursban 2E, 750 mL ➢ Malathion 500EC, 1.25 L ➢ Orthene 75SP, 1.0 kg ➢ Pyrate 480EC, 375 mL	Treat when adults first appear and repeat as required. Excessive fertilization or pruning can cause undesirable succulent growth levels. **Endosulfan* and *Thiodan* toxic to fish. [1] *Minimum reentry period is 48 hrs.*
	Eastern tent caterpillar	➢ Dursban 2E, 1.0 L ➢ Orthene 75SP, 1.0 kg ➢ Pyrate 480EC, 375 mL ➢ See under *MALUS*	**[Plate 31]**
	Japanese beetle	➢ See under *ROSA*	**[Plate 62 & 63]**
	Leafroller	➢ Orthene 75SP, 1.0 kg ➢ See under *MALUS*	
	Peachtree borer *(Synanthedon exitiosa)* Lesser peachtree borer *(Synanthedon pictipes)*	➢ *Endosulfan 50W, 1 kg ➢ *Thiodan 4EC, 1.5 L	Both borers attack various cultivated and ornamental *Prunus*. Peachtree borers attack tree bases. Lesser peachtree borers attack higher limbs. **[Plate 60]** Adults are clear–winged moths. Borers overwinter in bark or wood as partly grown larvae. Feeding resumes in spring, with gum and frass accumulating near the burrows. Treat in late–May or early–June, when *Philadelphus* is blooming. Repeat twice at 3–week intervals. Spray with a gun and cover trunk and scaffold limbs thoroughly. Use pheromone traps to monitor adult activity. **Endosulfan* and *Thiodan* toxic to fish.
	Pearslug	➢ Orthene 75SP, 1.0 kg ➢ See under *MALUS*	
	Uglynest caterpillar *(Archips cerasivoranus)*	➢ Methoxychlor 240EC, 4.0 L ➢ Sevin 50W, 2.0–3.0 kg	Dark, yellow–green larvae have black heads. Mainly attacks low–growing shrubs. Feeds on choke, pin, and black cherry. Webbed nests appear at branch ends between May and Sept. Prune out nests when found. Chemical control seldom used.
DISEASES	Bacterial canker *(Psedomonas syringae)*	➢ Clean Crop Copper Spray, 6.0 kg	Apply before fall rains and again when most leaves have fallen. Don't crowd plants—maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels.
	Blossom and twig blight *(Monilina fructicola)*	➢ Captan 50WP, 2.0 kg ➢ Captan 80WDG, 1.25 kg ➢ Cyprex 65WP, 500 g ➢ Daconil 2787F, 2.5 L ➢ Funginex 190EC, 750 mL ➢ Sulfur 90–95WP, 2.0 kg	Spring blossoms suddenly collapse and turn brown. Shoot or twig blight appears in early–spring. Fruit will turn brown, rot, and hang on the tree. Spray just before blossom buds open. Repeat in 10 days if wet weather persists. Prune out and destroy infected twigs. Remove infected fruit from tree and the adjacent ground.
	Black knot *(Apiosporina morbosa)*	Large black swellings up to 10 cm long on branches and small twigs eventually girdle and kill the branch. In late–winter and early–spring, prune and destroy infested twigs and branches several cm below knots. Eliminate wild or neglected *Prunus* species from the area.	
	Peach leaf-curl *(Taphrina deformans)*	➢ Ferbam 76WDG, 1.75-3.5 kg	As leaves unfold in spring, they become puckered and curled. Thickened areas eventually turn pinkish. Infected leaves become weakened and drop. Spores lodged in winter buds cause infections during spring. Apply fungicide in fall (preferred time) just after complete leaf drop OR apply in early spring just before buds swell.
	Shot–hole leaf spot *(Blumeriella jaapii)*	➢ Benlate, 1.1 kg + Captan 50WP, 4.5 kg ➢ Captan 80 WP, 1.25–1.5 kg	Leaf spots appear as leaves reach full size. New spots appear until late–summer. Spots fall out with age, giving a shot–hole appearance. (Other problems cause similar symptoms.) Avoid overhead irrigation late in the day. Don't crowd plants—maintain adequate sunlight and good air circulation.

PSEUDOTSUGA — Douglas Fir

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Cooley spruce gall aphid	➤ See under *PICEA*	**[Plate 36]**
	Tarnish plant bug	➤ See under *THUJA*	**[Plate 74]**

PYRACANTHA — firethorn

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Scab *(Venturia pyracanthae)*	➤ Daconil 2787F, 2.5 L	Plant scab–resistant cultivars. Clean up and destroy fallen leaves. Prune to improve air circulation through the canopy. Start fungicide applications when leaf buds begin to break. Repeat every 7–10 days during May and June, especially in rainy weather. Stop treatments if no infection exists at the end of June.
	Fire blight	➤ See under *MALUS*	

PRYUS — pear

	Pest	Control/1000 Litres Water	Remarks
DISEASE	Fire blight	➤ See under MALUS	**[Plate 33]**

QUERCUS — oak

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➤ See under *FAGUS*	
	Cankerworm	➤ Orthene 75WP, 1.0 kg ➤ See under *MALUS*	**[Plate 29 & 30]**
	European fruit lecanium	➤ See under *ULMUS*	**[Plate 4]**
	Golden oak scale *(Asterolecanium variolosum)*	➤ Cygon 480E, 2.5 L ➤ Dursban 2E, 4.0 L ➤ Ethion superior oil, 20 L ➤ Lagon 480, 2.5 L ➤ Orthene 75SP, 1.0 kg ➤ Pyrate 480EC, 2.0 L ➤ Sevin XLR PLUS, 2.3–3.5 L ➤ Superior oil, 20 L	Yellowish–golden scale feeds in small pits on white and English oak twigs, branches, and trunks. Can cause branch dieback. Use *superior oil* or *Ethion superior oil* as a dormant treatment in early–spring. Use any of the other materials against crawlers in late–June. Crawlers can appear on first year and current season wood.
	Gypsy moth	➤ See under *BETULA*	**[Plate 12 & 13]**
	Lacebug	➤ See under *FRAXINUS*	
	Lecanium scale	➤ See under *THUJA*	
	Oak leafminer *(Profenusa lucifex)*	➤ DZN 600 EW, 830 mL ➤ Diazinon 500EC, 1.0 L ➤ Malathion 500EC, 2.5 L ➤ Orthene 75SP, 1.0 kg ➤ Sevin 50W, 2.0–3.0 kg	Causes flat, blister–like mines from mid–June to July. Pale larvae with stubby black legs found in mines. Early treatment is most effective. Treat foliage to control larvae beginning the first week of June.
	Oak leaf gall (Several species)	➤ Chemical control usually not necessary	Many gall makers infest oak roots, bark, twigs, leaves, flowers, and acorns. Each gall has a characteristic appearance. Many are conspicuous and interesting, but few cause serious damage.

QUERCUS — oak

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Oak leaftier *(Croesia semipurpurana)*	➢ Sevin 50W, 2.0–3.0 kg ➢ Sevin 80S, 1.25–2.0 kg	Attacks only oaks. Small, whitish larvae enter unopened buds in May. They feed on the young leaves, then tie the leaves together and shred the tissue. Treat to control larvae when leaves are partially expanded.
	Oak red mite *(Oligonychus bicolor)*	➢ Kelthane 187.5EC, 2.5 L ➢ Orthene 75SP, 1.0 kg	Feeding bronzes and bleaches oak leaves. Treat upper leaf surface from mid–June to mid–July. Weather and predators often keep populations under control.
	Oak skeletonizer *(Bucculatrix ainsliella)*	➢ Malathion 500EC, 2.5 L ➢ Sevin 50W, 2.0–3.0 kg	Small yellowish–green larvae skeletonize the lower surface of oak leaves. One generation in June and a second in Aug.–Sept. Treat foliage when damage first appears in mid–June. Repeat in Aug. Collect and destroy leaves in the fall.
	Orangestriped oakworm *(Anisota senatoria)*	➢ Malathion 500EC, 2.5 L ➢ Methoxychlor 240EC, 4.0 L ➢ Sevin 50W, 2.0–3.0 kg ➢ Sevin 80S, 1.25–2.0 kg	The black larvae have orange or yellow stripes running lengthwise down the sides and back. Two stiff black horns project from the top of the second body segment. Small sharp spines on the other body segments. Treat, if necessary, in Aug. when larvae are young and concentrated on the lower branches.
	Oak twig pruner *(Elaphidionoides villosus)*	A long–horned beetle that attacks oak and some other deciduous trees. Larvae tunnel inside the twigs. Foliage on infested branches begins to wilt in mid–summer, and damaged twigs fall to the ground. Collect and destroy fallen twigs before mid–May and in the fall to remove pupae. Chemical control is difficult and impractical.	
DISEASES	Anthracnose *(Gnomonia quercina)*	➢ Daconil 2787F, 2.5 L ➢ Dithane M45, 2.75–3.5 kg	Causes irregular leaf–margin browning on red and white oak. Areas between veins also turn brown. Often develops after a cool, wet spring. Collect and destroy fallen leaves in the fall. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Chlorosis Leaf yellowing	A problem for *Quercus palustris*, pin oak, and *Q. rubra*, red oak, on high pH soils, pH>6. Also caused by poor soil conditions such as water logging and compaction.	
	Dieback	➢ See *ABIOTIC DISEASES*	
	Leaf spot Several fungi	➢ Daconil 2787F, 2.5 L	Well defined brown or black spots appear in the leaves. Treat when dormant or at bud swell. Maintain plant health. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Scorch	Abiotic	Irregular browning appears on leaf margins and between veins. Occurs late in the season and during dry weather. **[Plate 61]**

RHODODENDRON — rhododendron

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Black vine weevil	➢ See under *TAXUS*	**[Plate 68 & 69]**
DISEASES	Dieback *(Phytophthora)*	➢ Daconil 2787F, 2.5 L	Canker visible on the stem. Terminal buds and leaves turn brown and leaves droop and curl. May also affect the root and crown. Treat as new leaves emerge. Repeat every 7–14 days during wet weather. Prune out infected branches and avoid overhead irrigation late in the day. Don't crowd plants—maintain adequate sunlight and good air circulation. Don't plant near lilacs, a common host for this disease.

ROBINIA — locust

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Locust borer *(Megacyllene robiniae)*	➢ *Endosulfan 400, 1.25 L ➢ *Thiodan 4EC, 1.25 L ➢ Dursban 2E, 1.0 L ➢ Pyrate 480EC, 500 mL	Larvae are fleshy, white grubs that tunnel in black locust stems. Black and yellow beetles feed on goldenrod pollen in late–summer. Weakened trees break in the wind. Remove and destroy heavily infested trees. Maintain tree vigour—chemical control is difficult. Treat bark or trunk and larger branches to control adult beetles from mid–Aug. to late–Sept. (when goldenrod, *Solidago*, is blooming). **Endosulfan* and *Thiodan* toxic to fish.
DISEASES	Locust leafminer *(Odontota dorsalis)*	➢ Orthene 75SP, 1.0 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	Damages black locust leaves in adult and larval stages. Heavy infestations make trees unsightly. Two generations a year. The adult is a small, wedge–shaped black beetle with bright orange wing covers. To control adult beetles, treat foliage in spring, when leaves open fully, and in early–July.

ROSA — rose

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➢ Cygon 480E, 1.25 L ➢ See under *FAGUS*	
	Leafhopper	➢ See under *GLEDITSIA*	**[Plate 32]**
	Japanese beetle *(Popillia japonica)*	Adult beetle control: ➢ Imidan 50WP, 1.25 kg ➢ Sevin XLR PLUS, 2.3–3.5 L Larva control: ➢ Dursban Turf Insecticide, 4.5 L	Metallic green adults are about 13 mm long. Easily recognized by six tufts of white hair on each side of the abdomen. **[Plate 63]** As the beetles feed, they skeletonize and consume foliage. **[Plate 64]** Preferred hosts include members of the *Rosaceous* family, maple, birch, linden, and fruit trees. Spray when adults appear in early–July. Use pheromone traps and lures to monitor adult activity. Larvae are "C"–shaped milky white grubs about 25 mm long with brown heads and 3 pairs of legs. Distinguishable from other white grubs by a "V"–arrangement of spines on the underside of the abdomen. Larvae feed on fibrous turf roots and may feed on nursery stock roots. Before treating nursery field soils or containers, verify that a larva problem exists. Treat the soil when grubs are young and actively feeding near the soil surface. Apply insecticide to moist soil and irrigate the treated area with 1–20 cm of water.
	Rose chafer *(Macrodactylus subspinosus)*	➢ Methoxychlor 240EC, 4.0 L ➢ Sevin XLR PLUS, 2.3–3.5 L	A slender, long–legged, tan beetle, densely covered with short, dull yellow hairs. Beetles swarm in early–June and feed on the opening buds of many hosts. They later attack the flowers, fruit, and foliage. The larvae feed mostly on turf grass roots, but may attack the roots of tree seedlings. Monitor for rose chafer in June. It is often a problem in sandy soils. With small infestations, pick off beetles by hand. Adult control is difficult. Treat foliage thoroughly when beetles appear.
	Roseslug *(Endelomyia aethiops)* *(Allanthus cinctus)*	➢ Sevin XLR PLUS, 2.3–3.5 L	These sawflies feed on leaves from late–May to mid–June. Treat both leaf surfaces. *A. cinctus* may need a second treatment in mid– to late–Aug.
	Two spotted spider mite *(Tetranychus urticae)*	➢ Cygon 480E, 1.25 L ➢ Diazinon 500EC, 1.25 L ➢ Kelthane 187.5EC, 2.5 L ➢ Lagon 480, 1.25 L ➢ Morestan, 0.625–1.25 kg ➢ Orthene 75SP, 1.0 kg ➢ Pentac Aquaflow, 400 mL ➢ Vendex 50W, 0.5–1.0 kg	Attacked leaves become off color, stippled, or bronzed. Check leaf bottoms for mites and webs. Treat leaf bottoms beginning in early–June and repeat as needed. Monitor for mites by vigorously shaking a branch over a sheet of white paper.

ROSA — rose (cont'd)

	Pest	Control/1000 Litres Water	Remarks
DISEASES	Bacterial canker *(Pseudomonas syringae)*	➤ Clean Crop Copper Spray, 6.0 kg	Treat once in October and once in January. Treat during blight conditions in April and May with 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Don't crowd plants—maintain adequate sunlight and good air circulation. Excessive fertilization or pruning can cause undesirable succulent growth levels.
	Black spot *(Diplocarpon rosae)*	➤ Clean Crop Copper 53W, 6.0 kg ➤ Daconil 2787F, 2.5 L ➤ Funginex 190EC, 1.0 L	A common rose disease causing black spots on leaves. **[Plate 64]** Leaves may turn yellow and drop. Where possible, use resistant cultivars. Remove and destroy cankered canes. Spray every 7–10 days from mid–May, as leaves begin to emerge, until frost kills the foliage. Reduce spray intervals in cool, wet weather. Avoid overhead irrigation, especially late in the day—six hrs of wet leaves will permit an infection to start. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Botrytis	➤ Botran 75, 1.75 kg ➤ Daconil 2787F, 2.5 L	Apply fungicide before lifting for storage. Repeat during storage. Apply at first sign of disease and repeat every 10–14 days if needed.
	Crown gall	➤ See under *EUONYMUS*	
	Powdery mildew *(Sphaerotheca pannosa* var. *rosae)*	➤ Clean Crop Copper 53W, 6 kg ➤ Folpan 50WP, 2.0 kg ➤ Funginex 190EC, 1.0 L ➤ Meltatox, 2.5 L ➤ Sulfur 90–95WP, 6.0 kg	White powdery growth on leaves and shoot ends. Leaves become stunted and curled. Treat when symptoms first appear. Apply fungicide every 5–10 days. Don't apply sulphur when temperatures exceed 27° C. Alternate chemicals annually. Don't crowd plants—maintain adequate sunlight and good air circulation. Overhead watering *during the day* reduces the spread and development of the disease, but avoid overhead irrigation late in the day.

SALIX — willow

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➤ *Thiodan 4EC, 1.25–1.75 L ➤ Dursban 2E, 750 mL ➤ Malathion 500EC, 1.25 L ➤ Orthene 75SP, 1.0 kg ➤ Pyrate 480EC, 375 mL ➤ [1]Sniper 240E, 1.75–2.5 L	Treat when aphids first appear and repeat as needed. **Endosulfan* and *Thiodan* toxic to fish. [1] *Minimum reentry period is 48 hrs.*
	Gypsy moth	➤ See under *BETULA*	
	Imported willow leaf beetle *(Plagiodera versicolora)*	➤ Malathion 500EC, 2.5 L ➤ Methoxychlor 240EC, 2.5 L ➤ Orthene 75SP, 1.0 kg ➤ Sevin XLR PLUS, 2.3–3.5 L	A small, oval, metallic blue beetle. Adults and larvae skeletonize willow and Lombardy poplar leaves. Two or more generations per year. Larvae are black, slug–like grubs. Treat at first sign of leaf feeding after leaves appear, late–May to early–June. Repeat application in early–July if necessary. A pupal parasite exists, so avoid insecticide applications at that time.
	Oystershell scale	➤ See under *FRAXINUS*	
	Poplar and willow borer	➤ See under *POPULUS*	
	Spiny elm caterpillar *(Nymphalis antiopa)*	➤ Malathion 500EC, 2.5 L ➤ Sevin 50WP, 2.0–3.0 kg	Adult is called the "mourning cloak butterfly." Larvae are black with scattered white dots, and are covered with large, branched spines. They feed in groups on elm, willow, and poplar. Treat when caterpillars first appear and are small.
DISEASES	Blight — scab and black canker complex	➤ No chemical control	Leaves turn brown. Branches and twigs die back. Prune out infected wood. Don't crowd plants—maintain adequate sunlight and good air circulation.

SORBUS — mountain ash

Pest	Control/1000 Litres Water	Remarks
European red mite *(Panonychus ulmi)*	➤ Ethion superior oil, 20 L ➤ Malathion 500EC, 1.25 L ➤ Superior oil, 20 L	Use *superior oil* or *Ethion superior oil* as a dormant spray in early–spring. Use other materials about late–May. Apply oil when plants show ½ inch of green tissue and flower buds show as a tight cluster.
Japanese beetle	➤ See under *ROSA*	[Plate 62 & 63]
Mountain ash sawfly *(Pristiphora geniculata)*	➤ *Endosulfan 400, 1.25 L ➤ Dursban 2E, 1.0 L ➤ Malathion 500EC, 2.5 L ➤ Methoxychlor 240EC, 4.0 L ➤ Sevin 50W, 2.0–3.0 kg ➤ Sevin 80S, 1.25–2.0 kg	Yellow larvae with black spots on all body segments except the last one—4 lines of spots along each side of the larvae. Two broken lines run down the back. Pest feeds in colonies from June to early–Aug. A second generation appears from late–Aug. to early–Sept. Young larvae feed in colonies and are easily pruned out. Treat foliage to control larvae during June. Repeat treatment in areas where second generation appears in Aug. **Endosulfan* and *Thiodan* toxic to fish.
Pearleaf blister mite *(Eriophyes pyri)*	➤ Ethion superior oil, 20 L ➤ Sevin 50W, 2.0–3.0 kg	Causes small blisters on the bottom of pear, apple, and mountain ash leaves. Several generations per year. Mites overwinter under the outer bud scales, resuming activity in the spring. Apply *Ethion superior oil* as a dormant treatment in the spring. Apply *Sevin* as a foliar spray.
Rose chafer	➤ See under *ROSA*	
Apple scab	➤ See under *MALUS*	[Plate 34]
Fire blight	➤ See under *MALUS*	[Plate 33]
Leaf spot	➤ See under *CATALPA*	

SYRINGA — lilac

Pest	Control/1000 Litres Water	Remarks
Lilac borer *(Podesia syringae* var. *syringae)*	➤ *Endosulfan 400, 1.25 L ➤ *Thiodan 4EC, 1.25 L ➤ Dursban 2E, 1.0 L ➤ Pyrate 480EC, 500 mL	Adult is a dark brown, wasp–like moth, present from late–May to late–July. Adult emerges through holes 1–1.5 cm in diameter. [Plate 65] Larvae bore into the trunk near the base. Stressed trees are most susceptible to borers. Cut and destroy infested wood before May. Prevent mechanical damage to wood and bark. Use pheromone traps to monitor adult activity. Begin treatment 10 days after peak catch numbers. Treat trunk and large branches, especially around wounds. Repeat twice at 10–day intervals. **Endosulfan* and *Thiodan* toxic to fish.
Lilac leafminer *(Caloptilia syringella)*	➤ Cygon 480E, 1.25 L ➤ Lagon 480, 1.25 L ➤ Malathion 500EC, 2.5 L ➤ Orthene 75SP, 1.0 kg	Adult is a small, dark brown moth, active in late–May to early–June. Larvae are pale yellow and feed between leaf surfaces, causing brown blotches to form. [Plate 66] For small infestations, pick and destroy affected leaves. Treat when pest activity first appears, or apply initially in early–June or immediately after flowering and repeat 6 weeks later. *Ligustrum*, privet, is an alternate host.
Oystershell scale	➤ See under *FRAXINUS*	

SYRINGA — lilac (cont'd)

Pest	Control/1000 Litres Water	Remarks
Powdery mildew *(Microsphaera alni)*	➢ Sulfur 90–95WP, 6.0 kg	White to grey powdery mould appears on leaves in late–summer and early–fall. **[Plate 67]** Usually doesn't require chemical control. Don't crowd plants—maintain adequate sunlight and good air circulation. Overhead watering *during the day* reduces the spread and development of this disease, but avoid overhead irrigation late in the day. Apply fungicide when first symptoms appear in mid– to late–Aug. Repeat at 5–10 day intervals. Don't apply sulphur when temperatures exceed 27° C.
Bacterial canker *(Pseudomonas syringae)*	➢ Clean Crop Copper Spray, 6.0 kg	Young shoots or leaves turn black between early–spring and early–summer, especially during wet, cool weather. Kills young twigs during wet springs. Apply treatment once in October and again in January. During blight conditions in April and May, apply 1.0 g/L of active ingredient (2.0 g 50% wettable powder). Repeat at 7–10 day intervals. Avoid overhead irrigation late in the day. Prune out infected twigs. Don't crowd plants—maintain adequate sunlight and good air circulation.

TAXUS — yew

Pest	Control/1000 Litres Water	Remarks
Black vine weevil Taxus weevil *(Otiorhynchus sulcatus)*	➢ *Endosulfan 50W, 1 kg ➢ *Thiodan 4E, 1.25–1.75 L ➢ Sevin 50W, 2.00–3.0 kg	Larvae are small, white, legless grubs that eat fibrous roots or strip bark off larger roots. **[Plate 69]** Infested plants grow slowly or fail to grow and look dry and off–colour. Transplants often die without becoming established. Larvae control is difficult. Adults are black snout beetles that hide in soil litter during the day and cut crescent–shaped notches in needle margins at night. **[Plate 68]** They also attack arborvitae, hemlock, azaleas, and rhododendrons. The beetles have fused wing covers and cannot fly. To control adults, treat foliage, trunk bark, and branches during the last week of June and early–July. Spray in the evening, as adult activity increases about an hour after sunset. Don't use Thiodan on Anderson yew. Treat some conifer seedlings, especially pine, before treating larger area to test treatment safety. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. **Endosulfan* and *Thiodan* toxic to fish.
Fletcher scale *(Lecanium fletcheri)*	➢ Cygon 480E, 2.5 L ➢ Diazinon 500EC, 1.25. ➢ DZN 600 EW, 1.25 L ➢ Dursban 2E, 4 L ➢ Lagon 480, 2.5 L ➢ Malathion 500EC, 2.5 L ➢ Orthene 75SP, 1 kg ➢ Sevin XLR PLUS, 2.3–3.5 L	The adult is a reddish brown sphere that appears on branches. **[Plate 70]** Look for black sooty mold and honeydew on the needles. Heavily infested plants look off colour. Treat newly emerged crawlers in early–July when *Yucca filamentosa* is blooming, or in Sept. Repeat the application in about 10 days.
Taxus mealybug *(Pseudococcus cuspidatae)*	➢ Cygon 480E, 2.5 L ➢ Diazinon 500EC, 1.5 L ➢ Lagon 480, 2.5 L ➢ Malathion 500EC, 2.5 L ➢ Sevin XLR PLUS, 2.3–3.5 L	A slow–moving, white, woolly insect that can completely cover heavily infested branches and trunks with a waxy secretion. Feeding discolors needles and causes excessive needle cast. Attacks all yew species. Use insecticide on bark of small branches and twigs to control nymphs from late–May to mid–June. **[Plate 71]**

THUJA — eastern white cedar, arborvitae

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Cedar leafminer Arborvitae leafminer *(Argyresthia thuiella)*	➤ Cygon 480E, 2.5 L ➤ Lagon 480, 1.25 L ➤ Malathion 500EC, 2.5 L ➤ DZN 600EW, 830 mL	Four caterpillar species mine cedar, with *A. thuiella* the most common. Feeding causes branch tips to turn brown. **[Plate 72]** Adult is a small, light grey moth that appears in late–June to early–July. Prune out infected tips before June to provide some control. To control larvae, spray with *Cygon* in early–May or late–Aug. Use *Malathion* or *Lindane* in June to control moths.
	Black vine weevil	See under *TAXUS*	**[Plate 68 & 69]**
	Fletcher scale	See under *TAXUS*	**[Plate 70]**
	Juniper scale	➤ Diazinon 500EC, 1.25 L ➤ Dursban 2E, 4 L ➤ Malathion 500EC, 2.5 L ➤ Orthene 75SP, 1 kg ➤ Sevin XLR PLUS, 2.3–3.5 L	A small, circular, white scale with a yellow centre, it turns juniper and arborvitae needles yellow. **[Plate 22]** Treat crawlers in late–June when *Philadelphus* is at full bloom and *Catalpa* are beginning bloom. Repeat as needed about 10 days later.
	Spruce spider mite *(Oligonychus ununguis)*	➤ Sniper 50W, 0.925–1.25 kg ➤ Cygon 480E, 2.5 L ➤ Dursban 2E, 750–1000 mL ➤ Lagon 480, 2.5 L ➤ Malathion 500EC, 1.25 L ➤ Morestan 25WP, 0.625–1.25 kg ➤ Orthene 75SP, 1.0 kg ➤ Pentac Aquaflow, 400 mL ➤ Pyrate 480EC, 2.0 L ➤ Vendex, 0.5–1.0 kg	Use *superior oil* as a dormant treatment in early–spring. On blue spruce, use only wettable powders to prevent foliage discoloration; avoid *superior oil* and *Ethion superior oil*. Overwintering eggs hatch in late–April and early–May, when *Amelanchier* and *Acer platanoides* bloom. Prefers older needles as feeding sites. Control young nymphs with chemicals. Apply 2 sprays at 10-day intervals when mites exist in summer. Use miticides alone for maximum effectiveness. To monitor for mites, shake a branch over a white sheet of paper and look for crawling mites. Many predacious mites control populations. [1] *Minimum reentry period is 48 hrs.*
	Strawberry root weevil *(Otiorhynchus ovatus)*	➤ Ambush 500EC, 500 mL	Larvae are small, white, legless grubs that eat fibrous roots or strip bark from larger roots. The reddish brown flightless adult is under 6 mm long, and resembles the black vine weevil. Hides during the day and feeds at night. These pests have a large host range. Commonly injured plants include white cedar, spruce, and juniper. Adults are active in late–June and early–July, when *Wiegela florida* and *Syringa reticulata* are blooming. Adults injure plants by puncturing and girdling the current season's shoots while feeding. Infested plants grow slowly or fail to grow and look dry and off–colour. **[Plate 73]** Transplants often die without becoming established. To monitor for adults, wrap a sheet of burlap around infested plant bases. Adult weevils will hide in the burlap during the day. Place a white sheet under the plant and shake vigorously to dislodge any adults. *Ambush* is registered for use on seedlings. Treat some conifer seedlings, especially pine, before treating larger area to test treatment safety.
	Tarnish plant bug *(Lygus lineolaris)*	➤ Cymbush 250EC, 280 mL	Green adults are 6 mm long with dark markings. **[Plate 74]** They become active in early–spring. Use treatment in conifer seedling nurseries a maximum of 3 times per season. Don't use in greenhouses.
DISEASES	Botrytis	➤ Rovral 50WP, 1.2–2 kg/ha	During very humid conditions, a fuzzy grey growth develops on infected plant parts. Treat twigs and buds in spring before leaves develop. Treat conifer seedlings at the onset of Botrytis. Remove all fading and diseased plant parts promptly, especially when wet weather is predicted. Don't crowd plants—maintain adequate sunlight and good air circulation.
	Leaf blight (*Keithia*) (*Didymascella*)	➤ Copper spray, 4.0 kg ➤ Dithane M–45, 80WP, 2.75–3.5 kg ➤ Manzate 200DF, 2.75–3.50 kg	Mainly attacks western red cedar, *T. plicata*. Apply at 10–14 day intervals in April, May and early–June to protect new growth.

TILIA — linden, basswood

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➤ See under *FAGUS*	
	Cankerworm	➤ Orthene 75SP, 1.0 kg ➤ See under *MALUS*	**[Plate 29 & 30]**
	Linden looper *(Erannis tiliaria)*	➤ Malathion 500EC, 2.5 L ➤ Methoxychlor 240EC, 4.0 L ➤ Sevin 50W, 2.0–3.0 kg ➤ Sevin 80S, 1.25–2.0 kg	Bright yellow larvae have rusty brown heads and ten wavy black lines down the back. Present from early–spring to July. Feeds on a wide variety of hardwood leaves. Band specimen trees with sticky trapping materials in late–summer. This will trap wingless females as they climb up the trunk to lay their eggs. Treat foliage when infestation first appears.
	Two spotted spider mite *(Tetranychus urticae)*	➤ Kelthane 187.5EC, 2.5 L ➤ Pentac Aquaflow, 400 mL ➤ Vendex 50W, 0.5–1.0 kg	Leaves become stippled or bronzed. Treat leaf bottoms beginning in early–June and repeat as needed.
	Gypsy moth	➤ See under *BETULA*	**[Plate 12 & 13]**
	Japanese beetle	➤ See under *ROSA*	**[Plate 62 & 63]**
DISEASES	Canker	➤ See under *CANKER*	
	Verticillium wilt	➤ See under *ACER*	**[Plate 7]**

TSUGA — hemlock

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Black vine weevil Taxus weevil	➤ See under *TAXUS*	**[Plate 68 & 69]**
	Eastern hemlock looper *(Lambdina fiscelleria)*	➤ Foray 48B, 2.5–3.1 L/ha ➤ Sumithion 50EC, 0.56 L or split application at 0.35 L	A 30 mm long grayish caterpillar flecked with black dots. **[Plate 75]** Prefers hemlock, balsam fir, and white spruce, but will feed on several other coniferous and broadleaf hosts. *Sumithion* split application should be 3–6 days apart.
	Tarnish plant bug	➤ See under *THUJA*	**[Plate 74]**
	Botrytis	➤ See under *THUJA*	

ULMUS — elm

	Pest	Control/1000 Litres Water	Remarks
INSECTS	Aphid	➤ See under *FAGUS*	Don't use *Orthene* on American elm.
	Cankerworm	➤ See under *MALUS*	Don't use *Orthene* on American elm.
	Elm bark beetle: European elm bark beetle *(Scolytus multistriatus)* Native elm bark beetle *(Hylurgopinus rufipes)*	➤ Dursban 4E, 10.0 L ➤ Methoxychlor 240EC, 80.0 L ➤ Pyrate 480EC, 10 L	Elm bark beetles are vectors of the Dutch Elm Disease fungus. The smaller European elm bark beetle feeds in the crotches of small twigs. The native elm bark beetle attacks rough–barked branches and stems, causing distinct gallery formations. **[Plate 76]** Both are small, brownish beetles about 3 mm long. Destroy elms infected with Dutch elm disease before overwintering adult beetles emerge and lay eggs. To control beetles, treat on suitable days in March and April, before leaves appear on trees. Apply a second treatment in late–July.
	Elm casebearer *(Coleophora limosipennella)*	➤ Malathion 500EC, 2.5 L ➤ Sevin 50W, 2.0–3.0 kg	Overwintering larvae feed on emerging leaves. The larvae mine leaves. Heavy infestations cause leaf browning or scorching. All elms are potential hosts. Treat foliage in early–June as mines begin to appear.

ULMUS — elm (cont'd)

Pest	Control/1000 Litres Water	Remarks
European elm scale *(Gossyparia spuria)*	➤ [1]Sniper 50W, 2.0–2.5 kg	Overwintering nymphs become active in early–spring. Crawlers are covered in white, waxy cottony strands. By June, females can easily be seen by the white margins around the scale. Treat when young crawlers have emerged in July. [1] *Minimum reentry period is 48 hrs.*
Elm leafminer *(Fenusa ulmi)*	➤ Safer's Insecticidal Soap, 1% solution ➤ Sevin XLR PLUS, 2.3–3.5 L	Treat foliage around late–May to early–June to control larvae as mines first become apparent. For small infestations, mined leaves can be picked off and destroyed.
Elm leaf beetle *(Pyrrhalta luteola)*	➤ *Endosulfan 400, 1.25–1.75 L ➤ *Thiodan 4EC, 1.25–1.75 L ➤ Methoxychlor 240EC, 4.0 L ➤ Orthene 75SP, 1.0 kg ➤ Sevin XLR PLUS, 2.3–3.5 L	The adult beetle is olive–green with a dark stripe on each wing cover. The beetles chew holes in developing leaves, while the black larvae skeletonize the underside. May attack all elm species. Treat upper and lower leaf surfaces when they are about three–quarters expanded. Don't apply *Orthene* on American elm. **Endosulfan* and *Thiodan* toxic to fish.
Lecanium scale	➤ Superior oil, 20 L ➤ Ethion superior oil, 20 L ➤ Sevin XLR PLUS, 2.3–3.5 L	Use *superior oil* or *Ethion superior oil* as a dormant treatment in early–spring. Use other materials as foliar sprays to control crawlers (about mid–July).
European red mite	➤ See under *SORBUS*	
Gypsy moth	➤ See under *BETULA*	**[Plate 12 & 13]**
Leafhopper	➤ See under *GLEDITSIA*	
Dutch elm disease *(Ceratocystis ulmi)* *(Ophiostoma ulmi)*		Often begins as the wilting of large branches. May begin on 1 side of the tree. Leaves turn yellow and begin to flag or droop. Stripping away bark reveals stained wood. **[Plate 77]** Control elm bark beetles that carry fungus from diseased trees to healthy ones. Diseased/dead materials must be removed to control beetle populations that breed in them.
Dutch elm disease (*Ceratocytis ulmi)* *(Ophiostoma ulmi)*	➤ Alamo (see product label for rate)	A trunk-inject unit which introduces fungicide into the plant system. For use by trained arborists or others trained in trunk injection techniques. This product may be effective when used where i) 20% or less of canopy is showing wilt symptoms; ii) infested branches are removed at first sign of wilt; iii) leaves have fully expanded and plant is actively transpiring (June and July). Don't burn wood in year of treatment. See elm bark beetle.

VIBURNUM — virburnum

Pest	Control/1000 Litres Water	Remarks
Snowball aphid *(Neoceruraphis viburnicola)*	➤ *Endosulfan 400, 1.25–1.75 L ➤ *Thiodan 4EC, 1.25–1.75 L ➤ Dursban 2E, 750 mL ➤ Malathion 500EC, 1.25 L ➤ Orthene 75SP, 1.0 kg ➤ Pirimor 50WP, 500 g ➤ Pyrate 480EC, 375 mL	Overwinters in *Viburnum opulus* and *V. opulus sterilis* buds. Both are very susceptible. Doesn't seem to affect other species. Overwintering eggs hatch as buds begin to open in the spring. Feeding causes severe leaf distortion and twists young shoots. Treat foliage when aphids first appear (about mid–May) and repeat as needed. **Endosulfan* and *Thiodan* toxic to fish.
Viburnum leaf beetle *(Pyrrhalta viburni)*	Adults and larvae of this beetle skeletonize foliage of *Viburnum opulus*, European high bush cranberry, and its selections. **[Plate 79]** Eggs overwinter in twigs of last year's growth. Larvae hatch and begin feeding as leaves emerge in the spring. **[Plate 78]** Prune out and destroy terminal shoots (containing eggs) before May 1. **[Plate 80]**	
Downy mildew *(Peronospora rubi)*	Angular lesions appear between leaf veins. Undersides of leaves turn white from fungus. Plants often defoliate by mid–to late–season. Downy mildew needs moist conditions and cool or warm (not hot) temperatures. Don't crowd plants—maintain adequate sunlight and good air circulation. Avoid overhead irrigation late in the day. Collect and destroy infected plant material.	
Powdery mildew *(Microsphaera sparsa)*	➤ Daconil 2787F, 2.5 L	Don't crowd plants—maintain adequate sunlight and good air circulation. Overhead watering *during the day* reduces the spread and development of the disease. Avoid overhead irrigation late in the day. Apply fungicides when symptoms are first noticed, mid– to late to Aug. Reapply at 5–10 day intervals.

4. Rodents and Deer

Rodents and deer can cause significant injuries to nursery and landscape plants. Controlling them can be difficult, and often requires long term strategies. For additional information, refer to the OMAFRA Factsheet *Rodent and Deer Control in the Orchard*, Order No. 98-023.

Vole (Mouse) Control

Voles chew on roots and girdle tree/shrub stems and trunks. They have shorter tails than mice and ears that lay flat against their bodies. There are 2 types of voles — *pine voles* and *meadow voles*. The meadow vole is more common in Ontario.

Voles need shelter, food and protection from predators to survive. You can manage vole populations by eliminating one of these requirements.

In spring and summer, meadow voles feed on grass seeds, herbs and bulbs. In fall and winter, they feed on the bark of woody plants. Pine voles feed underground, mainly on rootlets, and strip the bark off larger roots. Meadow voles make shallow runways along the soil surface while pine voles burrow underground.

Vole Control Options

- In the landscape, maintain good weed control for a distance of at least 60 cm from tree trunks and shrub stems.

- In a nursery with cover crops between tree rows, maintain a herbicide strip at least 1.2 m wide at the base of each tree. Mow the cover crop short in late summer, since dense stands provide shelter to the rodents.

- Tree guards should extend about 45 cm up the tree trunk. Anchor guards firmly into the soil, about 8 cm deep. Keep them secure and free from trash.

- Where possible, encourage natural predators such as foxes, snakes, hawks, owls, dogs, and cats.

- Use poisoned mouse baits (rodenticides) where you have sustained past damage. Begin baiting the field border in October to help prevent voles from entering growing areas.

- Alternate between a zinc phosphide bait and an anticoagulant bait. We don't recommend multiple applications of zinc phosphide, as voles can become bait shy after the first application and remain shy for 2–4 months.

- Broadcast baits on sunny fall days when no rain is expected.

- If animals and natural predators are a concern, use bait stations. Set about 25 stations/hectare (10/acre).

Examples of bait stations include:
- **A 750 gram plastic yogurt container. Cut a hole in the lid and place the container on its side.**
- **A small, narrow necked, glass juice jar. Place the jar on its side**
- **Plastic "T"-shaped bait stations constructed of 11/2 inch ABS pipe.**

Precautions for Handling Poison Baits

It's important to handle poison baits safely.

- These baits are recommended for use with commercial nursery plantings only.

- Mark all poison bait storage containers POISON.

- Store poison baits away from children, irresponsible persons, pets, and livestock.

- Do not inhale zinc phosphide dust or fumes.

- Do not keep baits containing zinc phosphide in a building used by people or animals.

- Reserve all bait mixing and application equipment for that purpose alone.

- Wear rubber or other protective gloves, as you would when handling hazardous insecticides.

- Wash after handling poison baits.

- Keep dogs and cats that are enthusiastic mousers away from the nursery for at least two–three days to prevent them from catching dying mice.

- Don't handle dead mice or voles with bare hands.

- Dispose of dead mice and voles away human and animal contact.

Use Table 4-1 to select a suitable rodenticide for vole and mouse problems.

TABLE 4–1. Rodenticides

Method of action	Generic name	Trade name
Anticoagulant	brodifacaum	Ratak +
	chlorophacinone	Ground force Rozol
	diphacinone	Ramik brown Ramik green
Acute poison	zinc phosphide	Many products available

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Rabbit Control

Rabbits feed on the bark, twigs, and buds of many woody plants. They seem to prefer thinner–barked plants such as fruit trees, crabapple, flowering dogwood, sweetgum, holly, privet, pine, birch, and young maple.

Rabbit Control Options

- Fencing may provide control for smaller areas. Use a 25 mm mesh, staked every 2 m with sturdy posts. Secure the fence bottom in the ground. Rabbits will not burrow under the fence, but will squeeze through any opening they can find. Extend the fence at least 60 cm above the maximum snow level. Individual tree guards may also be used.

- Trap rabbits and remove them from the area.

- Encourage natural predators.

- Shooting rabbits can keep numbers low. Maintain this method of control all year round. Consult with local authorities regarding firearm bylaws and regulations.

- Use rabbit repellents to discourage feeding.
  - The rabbit repellent must have long–lasting adhesive qualities to be effective.
  - Repellants must taste unpleasant to the rabbit.
  - Put repellant on all plant parts that the rabbit can reach. Take into account the height added by deep snow.

- Chemical repellents consist of commercial Thiram–based mixtures (e.g., Skoot) and ammonia fatty acid soaps (e.g., Hinder).

- Mix Thiram with white exterior latex paint for an effective repellent. Combine 400 g Thiram 75WP with 2 L of water. Slowly stir this mixture into 4 L of white exterior latex paint. Don't use oil base paints, which are toxic to trees.

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Deer Control

Deer feed on the buds, shoots, and leaves of many woody plants. Feeding causes growth set back and poorly shaped plants.

Deer Control Options

- Fence plants preferred by deer (e.g., Taxus; rosaceous plants) to help keep them out. Use wire mesh at least 2.4 m high and supported by sturdy posts. Electric fences may provide some control.

- Hunt only in season. You may not kill deer while defending property. Contact your local office of the Ministry of Natural Resources regarding dates and permits.

- Repellents are not very effective against deer browsing. Place repellants before you see evidence of feeding. Reapply during the winter months. Repellants may succeed with thorough treatment when alternate food sources exist. When food is scarce, repellents may not work.

- Chemical repellents consist of commercial Thiram–based mixtures (e.g., Skoot) and ammonia fatty acid soaps (e.g., Hinder). Replace these taste repellents every 3–4 weeks. Apply when no rain is forecast for 24 hrs and temperatures range between 4–27° C.

Cover all susceptible plant parts. Spray outer portions of trees and shrubs to a height of 2 m.

- Odour repellents may discourage deer from feeding. Odour repellents include bloodmeal, moth flakes, perfumed soaps, and human hair.
  - Some research shows that soap bars hanging in the field discourage deer. Drill a hole in each bar of soap, leaving the wrapper in place. You can use small soap bars (e.g., those available from hotels). Any brand of soap apparently will work. Hang the soap from a branch about 75 cm above the ground using a twist tie or string. Each bar of soap will protect a radius of about one metre.
  - Bags of human hair may deter deer, though this has inconsistent results. Place 2 handfuls of human hair in some nylon socking or a fine mesh bag. Hang the bags on outer tree branches or from the perimeter of the area you want to protect. Place the bags up to 90 cm apart and 75 cm above the ground. Keep the bags in place from mid–fall to early–spring, replacing them monthly.

5. Controlling Weeds

A weed control program combines cultural, mechanical, and chemical methods appropriate to your situation. Effective weed control depends on weather conditions, soil type, and the cropping history on your farm. Before doing anything else, you need to identify your problem weeds and learn about their growth habits. See OMAFRA Publication 505, *Ontario Weeds*, for weed identification assistance.

Once you identify your problem weeds, you should minimize the potential problems before planting, eliminate possible weed sources, and prevent weeds from establishing.

Weed Control Principles

- You can avoid many weed problems by using weed–free crop seeds and transplants, and by preventing weeds from going to seed. Monitor weed growth in both crop and surrounding non–crop areas.

- Soil conditions that enhance microbial activity are a strong defense against weeds. Practices that increase soil biological activity (i.e., bacteria, fungi, earthworms, insects) can reduce weed problems. Biological activity can increase crop vigour while making weed seeds decay faster in the soil.

Reducing Weeds Before Planting

Cover Crops

If you remove a nursery–field from production, plant a cover crop or green manure before replanting the field.

- Plow down crops such as rye, red clover, buckwheat, sudan grass and oilseed radish are typical cover crops.

- Cover crops suppress weed growth through crop competition and allelopathy.

- Cover crops also reduce wind erosion of the soil and increase soil organic matter.

Controlling Perennial Weeds

The following perennial weeds can present problems for nursery crops: quackgrass, bindweed, vetch, wild grape, perennial nightshade, thistles, ground ivy and burdock, horsetail, toadflax, milkweed, asters, and goldenrod.

- Always attempt to minimize (or eliminate) perennial weeds in the preplanting year.

- If necessary, apply some chemical controls to perennial weeds in the preplanting year. Appropriate herbicides include Roundup and Amitrole–T. Follow the manufacturers' recommendations and always use the recommended application rate for the weed in question. You must apply herbicides at the proper stage of weed growth to achieve permanent control.

- Controlling perennial weeds among established plantings can be difficult given crop sensitivity to some herbicides and the inability to clean cultivate in established nurseries.

- Repeated cultivation controls some perennial weeds, such as bindweed.

- Use nonselective herbicides before planting a green manure crop and before plowing it under. Short–residual herbicides such as 2,4–D may be used with tolerant green manure crops. However, avoid herbicides that leave a soil residue in the planting year.

Crop Rotation

Crop rotation is important to any long–term weed control strategy.

- After plowing a cover crop, it's best to replant the field with different nursery stock. For example, if you previously grew conifers, plant deciduous stock. This permits a change in tillage methods, row widths, harvesting, and herbicide selection.

- Crop rotation helps break weed cycles and minimizes weed population increases. Short rotations using several crops will increase the yield and profit of each individual crop. You can improve weed control by choosing a crop that competes well with the problem weeds.

Stale Seedbeds

The stale seedbed technique involves preparing seed beds early in the growing season.

- Allow weeds to germinate.

- Several weeks later, control the weeds using glyphosate or paraquat.

- Once the weeds die, seed or transplant the crop into the bed, disturbing the soil as little as possible.

Preparing Container Beds

- Prepare container bed areas with a gravel layer and/or ground coverings (e.g., black plastic, opaque woven materials). These surface coverings must exclude light to prevent weed–seed germination. You can reuse the ground coverings for several years before replacing them.

- Keep container beds and roadways weed–free by physical removal or chemical mowing.

- Remove all pulled weeds and them discard well away from the growing area. Do not allow seeds into nearby containers.

- Remove existing weeds from container stock before they flower. Flowering weeds can disseminate hundreds of seeds by wind or by catapulting the seeds.

- Many container weed species have several generations/yr., since their seeds do not need to overwinter before germinating.

- Weed container stock thoroughly every fall, since many container–weed species overwinter in the protected environment of the polyhouse. Be sure to remove the rosettes of winter annuals such as shepherd's purse and Canada fleabane. Also remove the established plants and seedlings of common and mouse eared chickweed. If not removed, these plants will flower by May or earlier.

Eliminating Weed Sources

You can eliminate weed sources using mechanical, cultural, and/or chemical weed control measures.

- Control seed escapes with cultural removal or chemical mowing before the weeds set seed.

- Prevent weeds from setting seed in adjacent non–cropped areas.

- Mow at regular intervals to prevent weeds from flowering.

- Use string trimmers in appropriate areas, such as along fences.

- Find the source of weeds that disseminate into the field or container yard. These include poplars, willows, willowherb, and Canada fleabane.

- Control weeds around irrigation ponds to avoid sowing small–seeded weeds into container stock with each watering.

- Vigorous grassed banks help reduce weeds while stabilizing the bank.

- A filtering system in the irrigation line removes weed seeds.

Mechanical Weed Control

Mechanical weed control methods can reduce weeds and weed sources.

- Plant only weed–free seedlings and transplants.

- Don't bring one field's problems to another. Keep equipment free from weed debris when moving it between fields.

Rotary Hoes

Rotary hoes have fingers that lift and mix the soil, uprooting small weeds.

- Rotary hoes tend to damage crops less than harrows.

- Rotary hoes break up soil crusts and incorporate surface–applied herbicides into the soil. This activates the chemicals and improves the weed control.

- Use rotary hoes during late–morning or afternoon hours. Crop plants are more pliable at these times, reducing injuries, and hot sun can dry out the uprooted weeds.

- You must maintain sufficient speed (generally 10–20 km/hr) for satisfactory results.

- On light soils or with loose soil conditions, keep rotary hoes working shallow.

Inter-Row Cultivation

Inter–row cultivation or scuffling of row crops uproots small weeds and cuts off larger ones.

- Many kinds of equipment can perform this task.

- When using shovels, allow 50% overlap for thorough weed control. Keep the cultivation shallow and use shields to protect small crops.

- The first cultivation is crucial, since weeds escaping this pass usually grow to maturity.

- Row cultivation works well alongside herbicide applications. Shallow cultivation (2.5–5.0 cm) avoids disturbing any herbicides you applied.

Mowing

Mowing and cutting help to control weeds.

- Mow perennial weeds at the bud stage, when root reserves are low and seeds have not set.

- If you plan to apply a herbicide later in the season, allow sufficient time for weed regrowth after mowing.

Managing Herbicide Resistance

As of 1991, 120 herbicide–resistant weed species existed throughout the world. Triazine resistance is the only recorded problem in Ontario today. Herbicides must be treated as a resource to preserve. Strategies for preventing resistance follow from there.

Delaying Herbicide Resistance

Repeated herbicide spraying tends to create resistant weeds. Resistance develops at different rates with different herbicides, weed species, and weed populations. To minimize resistant weeds on your nursery, follow these steps:

1. *Identify and monitor weeds*
   Resistant weeds look exactly like susceptible weeds. "Escapes" are common after herbicide applications. Resistance usually becomes obvious only when ten–30% of a weed population becomes resistant. Survey your fields regularly and apply diagnostic methods to catch problems as they arise.

2. *Prevent weed spread*
   Clean all implements when leaving a field and never allow resistant weeds to go to seed.

3. *Use alternatives to chemical controls*
   Use mechanical weed controls, such as rotary hoeing or cultivation, wherever possible.

4. *Rotate crops and herbicides*
   Don't use the same herbicides every year. Rotate crops and spray the new crop with herbicides from a different group to prevent resistance. Where registered, use tank or formulated mixtures with multiple active ingredients that kill the same weed in different ways.

5. *Keep records*
   Keep accurate crop rotation and herbicide usage records for all of your fields. Long term weed control planning is easier with good records.

6. *Communicate*
   Consult with farmer organizations, universities, extension specialists, agribusinesses, friends, and neighbours about herbicide resistance problems. Inform your government and industry contacts of any resistance you encounter so they can act to prevent weed spread.

7. *Diagnose*
   Weeds that survive a herbicide application may not be resistant. It's important to rule out other factors that can affect herbicide performance. Examples include misapplication, unfavourable weather conditions, improper application timing, and weed flushes following a non–residual herbicide application. If resistance appears possible, check for the following:
   - Did the product control other weeds listed on the label? Chances are only one weed species will prove herbicide resistant in a given field situation. If several normally susceptible weed species exist, other factors probably caused the lack of weed control.
   - Did the same herbicide(s), from the same group, with the same action site fail in the same field area last year?
   - Did you use the same herbicide(s) from the same group year after year?

If at least one of these situations applies, your weeds may be resistant to the herbicide.

- Try controlling the weeds with a herbicide from another group or use appropriate non–chemical weed control methods.
- Do not let the weeds go to seed.
- Contact your OMAFRA Nursery Crop Specialist, herbicide supplier, and the appropriate chemical company to develop a comprehensive management program for the problem.

Chemical Weed Control

You may apply selective and non–selective herbicides to control weeds.

- Use selective chemicals to control weeds among crops.

- Use non–selective chemicals to control perennial weeds or on land not in crops (e.g., roadsides, fencerows, areas difficult to cultivate).

Herbicide Licensing Requirements

- You must have an exterminator's license to apply herbicides on property other than your own domestic property.

- Any person operating an extermination business must hold an operator's license.

For further information, contact the Ministry of Environment and Energy Pesticides Section, 135 St. Clair Avenue West, Toronto, M4V 1P5, or any Ministry of the Environment & Energy Regional Office.

Applying Chemical Herbicides

To successfully control weeds, you must apply the correct quantity of herbicide uniformly over a target area. While you can treat small areas with a garden sprayer, or even with a watering can, you'll need power equipment for larger areas. Whatever your application method, it's important to wet all weed foliage.

Herbicides are applied as emulsions, solutions, or suspensions. The volume to apply per hectare depends on the herbicide used and the crop being treated. Generally, apply low volumes (50–200 L/ha) of 2,4–D chemicals on emerged weeds. You must apply higher volumes (150–300 L/ha) of pre-emergent herbicides.

General Precautions

- **Selective weed control requires precision spraying equipment, expertly used.**
- **Herbicide drift can damage nearby plants. High pressure, small nozzle tips, herbicide dusts, and herbicide mists increase the damage risk. Take all possible precautions to prevent any drift from treated areas.**
- **Never apply herbicides in enclosed structures (cold frames or greenhouses) unless the manufacturer specifically recommends this use.**
- **Equipment used with 2,4–D–like chemicals must never be used to spray other solutions on 2,4–D–susceptible crops or garden plants.**
- **Do not apply herbicides using mist or air blast sprayers in agricultural areas of Ontario.**

Herbicide Drift

Herbicides can drift away from the intended target, damaging neighbouring plants and crops and impacting the environment. Drift injuries depend on the extent of herbicide escape and the susceptibility of the crops or plants it reaches. High–pressure sprayers and windy conditions increase the danger of drift.

When spraying herbicides, always guard against spray drift and vapour drift.

- Spray drift occurs when wind carries spray particles away from the intended target areas.

- Vapour drift comes from herbicide evaporation or volatilization. Vapours can escape during application or from droplets deposited on plant or soil surfaces. In addition to causing damage, vaporization reduces herbicide effectiveness.

To minimize drift:

- Do not spray in hot weather, windy weather, or when humidity is low.

- Use low pressures, larger nozzles, and a larger water volume.

- Since large droplets drift less than small ones, use the largest droplet size that gives the desired coverage and distribution. To choose nozzles that produce large droplets, follow these guidelines:
  - A narrow spray angle nozzle produces large droplets

- A larger orifice produces larger droplets
- A lower operating pressure produces larger droplets

When To Use Herbicides

Herbicides must be applied when both crop resistance and weed susceptibility are high. The timing depends on the herbicide, the weeds needing control, and the crop. Several different terms describe when herbicides may be applied. Unless otherwise stated, these times refer to the crop plant's development stage.

Application Technology

Always take care to apply herbicides correctly. Incorrect application can waste pesticide, compromise control, damage crops (possibly your neighbors') and contaminate the environment. New equipment and control systems can make herbicide application simple and precise.

New Technologies

Equipment manufacturers now work closely with the crop protection industry to refine application systems.

- Computerized sprayer controllers and ground speed radar are available today. These provide accurate application monitoring and control.

- Upcoming developments in application technology include closed injection systems (which separate the herbicide concentrate from the water carrier) and drift reduction using air assists and electrostatic methods.

Sprayers for Home Use

Use a 9–14 L knapsack or compressed air garden sprayer on lawns and around the home.

- A nozzle tip producing coarse spray minimizes spray drift.

- Keep spray pressure low—pressures up to 700 kPa are easily obtained. High pressures produce smaller spray droplets that can drift in light winds to susceptible garden plants.

- Use the sprayer for herbicides exclusively.

Field Sprayers

Use boom–type sprayers for field herbicide applications. These sprayers apply herbicide evenly across the width of the boom. To spray fields effectively, always maintain:

- uniform spray pressure
- constant forward speed
- stable boom height (to assure uniform overlap of the nozzle tip patterns)
- an application rate of 55–450 L/ha

Air Blast or Mist Sprayers

Never use air blast or mist sprayers to apply herbicides. They can cause herbicidal damage far from the target treatment area.

Wiper Applicators for Selective Weed Control

Wiper applicators (e.g., rope–wick, roller applicator) are commonly used with glyphosate (Roundup). Check product labels for information about using this technique with other herbicides. Labels will list the crops for which wiper application is registered. To use wiper applicators:

- follow manufacturers' directions
- contact enough of the target weed to get herbicidal effectiveness
- keep the applicator above desirable vegetation to avoid crop injury
- maintain a vehicle speed of 4–10 km/hr
- make a second pass, especially in heavy weed infestations or if using a higher vehicle speed
- avoid contact with sucker growth in orchards, vinelands, and shelter belts

Equipment Use and Care

Spraying Speeds

Uniform application rates require a constant forward speed whenever spray nozzles deliver liquid. If a tractor's driving wheels slip on the soil surface, the tractor's speedometer won't indicate a change in forward speed.

- To monitor forward speed despite wheel slippage on hills, use an independent speedometer with a ground driven wheel.

- Install spray monitors and other electronic rate controllers. These automatically correct for tractor speed variations to maintain a constant application rate.

Using Water Correctly

- Mix herbicides with clean water that does not contain debris, sand, or mud.

- Never let the water intake screen rest on a pond bottom when filling a sprayer.

- The water intake line near the screen must, by law, have a check valve or backflow device. This prevents water–source contamination when the pump is shut off.

- Do not use a tank-refilling nozzle, volume–booster nozzle, or injection pump when refilling sprayer tanks from ponds or streams. These tank–refilling aids may contaminate the water source.

- When using a farm water supply, install a frost–free water hydrant outside the building. Place a backflow valve/siphon on the discharge end of the hydrant.

Agitation

You must return spray solution to the sprayer tank to provide hydraulic agitation within the tank.

- To be effective, the return or bypass line from the pressure regulator must deliver liquid to the tank *bottom*.

- Return 2–14 L/min. to the tank when applying *chemical formulations* in solution.

- Return 14–27 L/min. for each 450 L of tank capacity when spraying wettable powders. The appropriate rate depends on the *wettable powder* concentration and the size of the tank.

  Wettable powders need a special line from the pressure side of the pump (not the pressure regulator) to the tank for adequate hydraulic agitation using a venturi jet or sparge tube. Sparge tubes need more water than venturis to provide the same agitation. You can reduce the flow rate if the sprayer tank has a mechanical agitator.

Preparing a Wettable Powder and Oil or Emulsifiable Concentrate Mix

To prepare a tank mix of wettable powder and an oil or emulsifiable concentrate, follow these steps unless the product label states differently:

1. Fill the sprayer tank with water to the half full mark.

2. Start the agitator.

3. Add a premixed slurry of wettable powder and water.

4. Agitate for 2–3 minutes before adding more water.

5. Add the oil or emulsifiable concentrate last.

6. Do not over–agitate the mixture. It may become a grease–like mass that settles to the tank bottom. In addition, over agitation may cause the mixture to foam excessively.

7. After any break from spraying, agitate the tank thoroughly before resuming.

8. Empty the tank completely before refilling to prevent oil buildup in the sprayer.

9. Clean the tank and sprayer with a detergent or solvent immediately after use, then flush thoroughly with clean water.

Pumps

Sprayer pumps must supply adequate capacity, pressure, volume, and agitation for the task at hand.

- Use *piston, diaphragm,* or *centrifugal* pumps for wettable powder suspensions.

- Use any of the above plus *roller pumps* for liquid herbicide applications.

- Pumps used for wettable powders and flowable formulations should have abrasion–resistant housings.

- Follow the manufacturer's care and storage instructions for optimum pump performance.

- Running a spray pump without water may cause premature wear or damage

Nozzles

Accurate spray application requires high quality nozzle tips. They must emit a uniform spray pattern at an expected rate. You can purchase *machined orifice* and *moulded orifice* tips made from materials ranging from *brass, stainless steel,* and *hardened stainless steel* to non–metals such as *plastics/polymers* and *ceramics.* Choose an appropriate tip using the guidelines below and examine the tip's spray pattern before each use. Then maintain a stable boom height to assure uniform spray pattern overlap and to prevent missed weeds in the target area.

- All herbicide formulations cause orifice wear, especially *wettable powders.* Replace nozzle tips when they deliver 10% more spray than they did when new.

- Worn nozzle tips spray unevenly and can produce streaks across a field by delivering too much herbicide to a given area.

- Always clean nozzle tips and screens thoroughly. Remove them from the nozzle body and wash with soap, water, and a bristle brush. Flushing water through the boom and nozzles will not remove pesticide residue buildup on the nozzles.

Flat-Fan Nozzle Tips

- Flat–fan nozzle tips work well with boom–type herbicide sprayers. Flat–fan tips may be colour coded for size (i.e., output). Some colour–coded tips have stainless steel, ceramic, or plastic/polymer inserts or are used for specialized applications. Always read manufacturers' labels carefully.

- Set spacings, boom height, and pressure as per manufacturer's recommendations. If not otherwise stated, maintain spray pressure at *275 kPa* for standard elliptical–orifice flat–fan tips. (Some flat–fan nozzle tips operate at a reduced pressure of approximately *140 kPa*. These tips reduce the risk of drift.)

- Maintain a full overlap spray pattern by using *110–series* of flat–fan nozzle tips (instead of *80–series* tips) with the same 51 cm spacing and the same height as the 80–series tips. This reduces misses should the boom bounce while traversing rough ground.

- You may obtain special "even spray" nozzle tips for herbicide band applications. The nozzle's tip height, spray angle, and orientation to the traveling direction combine to control the sprayed bandwidth. Follow manufacturers' directions closely.

Flooding-Fan Nozzle Tips

- Flooding–fan nozzle tips have a wide spray angle. They can be used closer to the ground, and at lower pressures, than flat–fan tips. This reduces drift.

- Flooding fan nozzle tips come in brass, plastic/polymers, and stainless steel. They cover roughly twice the width as flat–fan nozzle tips. However, they tend to distribute herbicides less evenly than flat–fan tips.

Broadcast Nozzle Tips

- Broadcast nozzle tips cover a very wide swath.

- Use broadcast nozzle tips for lanes and fence rows where you don't need a uniform spray pattern.

- Never use a broadcast–type nozzle tip near a susceptible crop. The spray may drift severely with even a light breeze.

Full and Hollow Cone Nozzle Tips

You can use full or hollow cone nozzle tips to spray the soil surface when the herbicide is incorporated into the soil with a disk harrow, cultivator, or similar tillage implement.

Nozzle Screens

You may obtain ball–check and plain nozzle screens. Ball–check screens use a diaphragm check valve on each nozzle to minimize dripping from the boom.

- Never mix screen types in a spray boom, since different screen types produce different flow rates through the nozzle.

- Always clean nozzle screens thoroughly. Remove them from the nozzle body and wash with soap, water, and a bristle brush. Flushing water through the boom and nozzles will not remove pesticide residue buildup on the nozzle screens.

Cleaning the Sprayer

- Clean sprayers immediately after spraying each day *and* whenever you change chemicals. Delaying even overnight allows persistent deposits to form.

- Don't neglect any sprayer parts. Clean the spray tank, booms, hoses, nozzles, tips, screens, filters, strainers, and pumps. Be sure to remove every trace of herbicide.

- Cleaning techniques depend on the herbicides applied. Many herbicides list tank–cleaning information on the label — always follow these instructions. If necessary, contact the pesticide manufacturer to learn the best cleaning methods for a product. If you can't get specific cleaning instructions, use a strong detergent or alkaline cleaner. Then rinse thoroughly.

- *Surfactants* may remove pesticide residues from spray equipment. Be sure tanks containing herbicide/surfactant (e.g., *Agral 90*) mixtures are scrupulously clean. Otherwise, the mixture may remove residues from the spray equipment, adversely affecting the crop.

Environmental Issues when Cleaning

- Before cleaning the sprayer, you must dispose safely of any surplus tank mix. The *Grower Pesticide Safety Course* suggests diluting the remaining spray solution at least 1:10 with water. You can safely apply this diluted solution to the previously treated area if you don't exceed the maximum application rate on the product label.

- Equipment used with *2,4–D*, *MCPA*, or related *phenoxy* herbicides must never be used to spray other types of solutions on 2,4–D–susceptible crops or garden plants. Never store these products near greenhouses or other areas with susceptible crops.
- The wash water contains herbicide. Never allow wash water into a well, lake, pond, river, or other water source.
- See Agriculture Canada Publication 1849/E, *Field Sprayers*, for more information.

Sprayer Calibration

Calibrate sprayers frequently, especially when spraying wettable powders. Wettable powders erode the nozzle opening. As a nozzle wears, the quantity of herbicide delivered increases and distribution becomes uneven.

Determining Application Rates in L/ha

There are many ways to calibrate a sprayer or determine the amount herbicide applied to one hectare of land. We suggest these 2 methods:

Method 1:

This method uses a graduated cylinder calibrated in millilitres. See OMAFRA's website at *www.gov.on.ca/OMAFRA/english/crops/sprayer/ep75.htm* for more detailed instructions.

1. Set 2 stakes 50 m (164 ft) apart in the field or along a fencerow beside the field.
2. Select the tractor gear and throttle setting you will use while spraying. With the sprayer half full of water, do a test run to determine how many seconds it takes to travel the 50 m course. Repeat the trial at least 3 times to get an average time. Avoid previous wheel tracks in the field.
3. Mark or note the throttle setting and/or rpm's on the tachometer. Do not change the throttle setting when stopping for next step.
4. Operate the sprayer while stationary. Use the desired pressure and the same throttle setting or rpm's used in the test runs. Spray for the length of time it took to travel 50 m. Collect the spray from each nozzle in a graduated cylinder (in millilitres).
5. Average the output per nozzle in millilitres. Clean or replace any nozzle more than 5% above the average nozzle output. Then reinstall all cleaned/new nozzles and recalibrate.
6. Measure the boom's nozzle spacing in metre.
7. Check the calibration rate in the field using herbicide solution in the sprayer. The type or quantity of herbicide in the tank may produce a different flow rate than plain water.

$$\textbf{Application rate} = \frac{\textbf{(mL liquid per nozzle) x (0.2)}}{\textbf{nozzle spacing (m)}}$$

Conversion factors:

L/ha x 0.4 =L/acre
L/ha x 0.11 = U.S. gal/acre
L/ha x 0.09 =Imp. gal/acre

Sample Calculation:

Time to travel 50 metres:	24.5 seconds
Liquid collected/nozzle for 24 seconds:	525 mL
Nozzle spacing on the boom:	0.5 metres

$$\textbf{Application Rate} = \frac{525\ \text{mL} \times 0.2}{0.5\ \text{m}} = 210\ \text{L/ha}$$

Conversions:

210 L/ha x 0.4 = 84 L/acre
210 L/ha x 0.11 = 23 U.S. gal/acre
210 L/ha x 0.09 = 18.9 Imp. gal/acre.

Method 2:

1. Set 2 stakes 200 m (656 ft) apart in the field. Do not use a different distance. A different distance won't work, as this method divides the number of square metres in 1 ha by the distance traveled as follows:

$$\frac{10{,}000\ \text{m}^2}{200\ \text{m}} = 50$$

2. Add enough clean water to the sprayer to make the following precalibration adjustments.

3. Adjust the boom height to obtain the sprayer manufacturer's recommended overlap for the nozzle tips and nozzle spacing used. For example, the boom should be 53–58 cm above the surface to be sprayed with a spray angle of 65°. For a spray angle of 80°, the height should be 42–48 cm above the target surface.

4. Operate the sprayer. Adjust the bypass relief valve to give the desired pressure with the nozzles operating. This also ensures that the sprayer lines are filled with water.

5. Fill the tank and place it on a level surface. Then record the water level on the tank's sight gauge or with a measuring stick.

6. Spray between the stakes in one direction, maintaining a set speed and pressure. Turn the boom "on" as you pass the first stake and "off" as you pass the second. Mark the throttle setting.

7. Return the sprayer to the same level location as before the calibration run. Carefully measuring the added water, refill the tank to the original mark on the sight gauge or measuring stick.

8. Calculate the application rate in litres per hectare using this formula:

$$\text{litres / hectare} = \frac{\text{litres of water added} \times 50}{\text{swath width in metres}}$$

Sample Calibration Calculations

Overall Spraying

If the sprayer's swath width is 6.5 m and you need 30 L of water to refill the tank, the application rate in L/ha is:

$$\frac{30 \times 50}{6.5} = 231 \text{ L/ha}$$

Band Spraying

With band spraying, acreage sprayed is not the same as crop acreage. The herbicide rates given in this publication apply to the area actually sprayed.

If the sprayer has 10 nozzles and each nozzle covers a 36 cm (0.36 m) band, the swath width is:

10 x 0.36 or 3.6 m

If you need 10L of water to refill the tank, the application rate in L/ha is:

$$\frac{10 \times 50}{3.6} = 139 \text{ L/ha}$$

Determining the Number of Hectares Per Tankful

Once you calibrate the sprayer, determine the number of hectares you can spray with a full tank as follows:

$$\frac{\text{tank capacity in litres}}{\text{L/ha}} = \text{ha/ tank}$$

For example:

$$\frac{450 \text{ litre tank}}{110 \text{ L/ha}} = 4.1 \text{ ha / tank}$$

If your tank is marked in Imperial gallons, convert to litres:

Imperial gallons x 4.5 = L

80 Imperial gallons x 4.5 = 360 L

If your tank is marked in U.S. gallons, convert to litres:

U.S. gallon x 3.8 = litres

100 U.S. gallons x 3.8 = 380 litres

Calibrating Hand-Held and Backpack Sprayers

Many people use small hand–held or backpack sprayers to treat problem areas or spray areas that were missed. Like your field sprayer, small sprayers must be calibrated accurately.

Method 1:

1. Set 2 stakes 50 m (164 ft) apart in the field.

2. Fill the sprayer ½ full with water.

3. Walk the 50 m course 3 times at a uniform pace. Calculate your average time to travel the course.

4. Measure the width (in metres) of the band sprayed by the nozzle at your walking pace.

5. Pump the sprayer, collecting liquid from the nozzle into a measuring device for average time noted in step 3.

6. Determine the application rate:

$$\text{litres / ha} = \frac{\text{mL liquid / nozzle} \times 0.2}{\text{Band width in metres}}$$

Method 2:

1. Partially fill the sprayer. Pump to the pressure you will use during the pesticide application.
2. Spray to determine the *swath width* (in metres).
3. Walk at a steady pace for 15 sec. Measure the distance you travel (in metres) during that time.
4. To calculate the *area* (in m^2) sprayed in 15 sec., multiply the *swath width* (determined in step 2) by the *distance travelled* (determined in step 3). This area is A.
5. Spray into a measuring device for 15 sec. The amount of solution (in litres) sprayed in 15 sec. is **B**.
6. Determine the application rate:

$$\text{litres / ha} = \frac{B \times 1000}{A}$$

Convert any pesticide application rate to the amount needed for a small area as follows:

1 kg/ha = 10 g/100 m^2.

For liquids, 100 L/ha = 1 L/100 m^2

Determining the Herbicide Quantity Required

- The common name of each herbicide listed in this publication (i.e., its active ingredient) appears in lower case letters (e.g., *napropamide, oxidiazon. glyphosate*).
- The product TRADE NAMES appear in caps (e.g., *DEVRINOL, RONSTAR, ROUNDUP*). We state the total substance (e.g., liquid, powder) in the container as supplied by the manufacturer. Its formulation appears in brackets following the trade name.
- Herbicides in this publication are specified by quantity of *active ingredient* (i.e. *common name) per hectare* and by quantity of *product TRADE NAME per hectare.*
- If the specified rate is "product per hectare," simply use that amount.
- Always verify product labels before use to confirm the amount of active ingredient it contains.

Materials, Mixing, and Mixtures

Dry Formulations

- Dry herbicide formulations come as granules, soluble powders, and wettable powders.
- Granules don't require mixing — simply apply them as is. Many herbicides used for pre-emergent treatments come in granular formulations. Performance usually equals that of the comparable liquid. Available equipment provides satisfactory distribution.
- Soluble powders should be dissolved in water.
- Wettable powders do not dissolve in water. They form a suspension requiring constant agitation.

Liquid Formulations

- Many liquid herbicide formulations form a solution when mixed with water.
- Oil–based liquid herbicides form an emulsion requiring constant agitation. Emulsions appear milky.

Mixing Herbicide Formulations

- Some herbicides can be combined with other chemicals in a single application. These combinations must be registered. Do not apply herbicide mixtures or herbicides mixed with other pesticides or foliar fertilizers unless the combination is registered for your intended use.
- Before mixing herbicides, consult package labels for compatibility information. Some formulations may react when mixed together, creating materials with new properties and activities.
- When using multiple herbicides together, mix one with the appropriate quantity of water. Then add the second. This reduces the formation of gums and precipitates that might clog nozzles and filters.
- Where water has a high salt content, test water/chemical compatibility before spraying. Use the mixture at field strength in a small area and monitor the results.

- Do not use surfactants or detergents in spray solutions unless specifically recommended by the herbicide manufacturer or this publication.

Application Indicators

You may obtain *colourants* and *foam markers* from agricultural chemical dealers. These indicators make accurate applications easier.

- Foam marking systems help the applicator minimize overlap.

- Colourants added to a pesticide solution make the applied material more visible. For example, colouring a herbicide used on cut stumps of woody plants helps assure thorough coverage without respraying; water-soluble colourants make lawn spraying easier. Available colourants include:

  Bullsey Basal 55 blue, oil soluble
  Blazon blue, water-soluble
  Bas-oil Red, oil soluble

TABLE 5–1. Herbicides Registered in Ontario (by Trade Name)

Trade Name	Common Name
BASAMID	dazomet
BONANZA	trifluralin
CASORON	dicholbenil
CIPC	chloropropham
DEVRINOL	napropamide
DUAL MAGNUM	s-metolachlor
EXPEDITE GRASS & WEED	glyphosate
GRAMOXONE	paraquat
KERB	propyzamide
PRINCEP NINE-T	simazine
RIVAL	trifluralin
RONSTAR	oxadiazon
ROUNDUP	glyphosate
SIMADEX	simazine
SIMAZINE	simazine
TERR-O-GAS	methyl bromide/ chloropicrin
TOUCHDOWN	glyphosate
TREFLAN	trifluralin
VAPAM	metam sodium
VORLEX PLUS	methyl isothiocyante/ dichloropropene
VORLEX PLUS CP	methyl isothiocyante/ dichloropropene/ chloropicrin

A Compendium of Herbicides with their Recommended Uses in Ontario — 2000

Products appear alphabetically by common name below. Trade names listed under each common name appear alphabetically. All listed products are registered for the listed purpose. The order in which products appear does not constitute a preference ranking.

TABLE 5–2. Herbicides Registered in Ontario (by Common Name)

Common Name	Trade Name
chloropropham	CIPC
dazomet	BASAMID
dicholbenil	CASORON
glyphosate	EXPEDITE GRASS & WEED ROUNDUP TOUCHDOWN
metam sodium	VAPAM
methyl bromide/chloropicrin	TERR-O-GAS
methyl isothiocyante/ dichloropropene	VORLEX PLUS
methyl isothiocyante/ dichloropropene/chloropicrin	VORLEX PLUS CP
napropamide	DEVRINOL
oxadiazon	RONSTAR
paraquat	GRAMOXONE
propyzamide	KERB
s-metolachlor	DUAL MAGNUM
simazine	PRINCEP NINE-T SIMADEX
trifluralin	BONANZA RIVAL TREFLAN

Preplanting Treatments

Some preplant herbicides act on germinating seedlings, while others also kill weed seeds.

- Apply preplant herbicide treatments before you sow or plant.

- You must incorporate most preplanting materials into the soil soon after application. We provide incorporation instructions when these herbicides are recommended.

Soil Fumigants

Fumigants generally control nematodes and soil diseases. They can control weeds at higher application rates.

- Before applying fumigants for nematode control, analyze your field soil's nematode count. See the Appendix for sampling instructions. Ensure nematodes are a problem needing treatment before using chemicals.

- Carefully follow the fumigant manufacturer's directions for dosage and methods of use.

- Wear a suitable respirator and full protective gear when using fumigants. Telone, Vapam, Vorlex, and methyl bromide are extremely toxic to the applicator. See Section 1, Pesticides, for safety details.

To use preplant fumigants effectively:

- Fumigate in the fall when soil temperatures are above 4° C. Fumigant dispersal improves at warmer soil temperatures (above 15° C).

- Remove trash and old root systems.

- Work the soil to a depth of 25–30 cm. Tilth and moisture should be in good seedbed condition.

- Inject the fumigant about 30–40 cm deep.

- Pack or water immediately after injection to seal the soil surface.

- Ideally, leave the soil undisturbed until spring. Delay necessary fall planting until at least one week after the fumigant injection. Colder soils (below 15° C) require longer periods from injection to aeration.

- Work and aerate the soil for about a week before planting. For fall planting, aerate the soil for at least two weeks after working.

- Rye grass has been recently linked with high populations of nematodes. Try using non-traditional types of annual cover crops such as pearl millet and sorghum Use Italian rye grass as an annual cover crop—they it are is a poor hosts for root lesion nematode. Contact the Nursery Crops Specialist for more detailed information

Common Name: dazomet

Trade Name: **BASAMID**

Chemical Family: **Dithiocarbamate**

Rates of Application:

dazomet	500.0 kg/ha
BASAMID (98Gr)	510.0 kg/ha

Sensitive Weeds:

Most germinating weed seeds.

Uptake and Translocation:

Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.

Basis of Selectivity:

Non–selective. Chemical must dissipate completely from the seedbed before planting or injury may occur.

Application Methods:

Apply granular product to a well–worked seedbed and incorporate evenly. Seal soil immediately after incorporation by rolling and flooding or by covering with heavy polyethylene plastic and sealing the edges. After waiting 10–40 days, depending on soil temperature, aerate the soil. Conduct a safety germination test before using treated soil. Do not use when soil temperature is below 6° C. Refer to manufacturer's directions for specific details and directions on sealing soil, evacuating gases, and performing the safety germination test.

Residual Activity:

Depends on the rate applied, soil moisture, and soil temperature. The gases are toxic to all growing plants. Perform a safety germination test before planting.

Unique Characteristics:

Also controls unencysted nematodes and soil fungi.

Manufacturer: *BASF*

Common Name: metam sodium

Trade Name: VAPAM

Chemical Family: Thiocarbamate

Rates of Application:

metam sodium	1250.0 kg/ha
VAPAM (380 g/L)	3287.5 L/ha

Remarks:

Field replant sites of ornamentals and forest tree stock.

Sensitive Weeds:

Most scarified weed seeds and freshly vegetative parts, including rhizomes and germinating seedlings.

Basis of Selectivity:

Most plant parts are sensitive. Don't plant crops until all fumigant dissipates from the soil. With moisture, it releases methyl isothiocyanate gas. This kills most scarified seeds and fleshy vegetative parts (including rhizomes and germinating seedlings).

Application Methods:

Apply as a drench to soil wet at least 8 cm deep. Apply uniformly using injectors, water, or other incorporation tools that carry the product to the desired depth. May be applied via the irrigation system. No gas–proof cover needed except for very porous soil. Apply water via sprinklers to provide a surface water seal. Do not plant for 10–14 days (or longer if the weather is cool). All traces of toxic gas must dissipate from the treated soil before planting to prevent plant injury.

Residual Activity:

10–40 days, depending on soil temperature and the amount of organic matter in the soil. Greatest persistence at low temperatures and with high organic matter levels. Plant 12–16 days after treatment following a lettuce seedling bioassay that indicates no injury.

Unique Characteristics:

Also controls nematodes, soil fungi, and soil insects.

Manufacturer: *Zeneca*

Common Name: methyl bromide / chloropicrin

Trade Name: TERR-O-GAS

Chemical Family: Organohalogen

Remarks:

Methyl bromide is very poisonous to humans and livestock. Only experienced, licensed operators may use it.

Sensitive Weeds:

Gas is toxic to germinating seedlings.

Application Methods:

Formulated as a pressurized liquid which, when released from its container, forms a gas. Product must be applied under a gas proof cover, usually plastic. Soil must be sealed with a plastic sheet since the gas is highly volatile. Refer to the label for detailed directions.

Methyl bromide gas is very volatile, and highly poisonous to humans and livestock. Inhalation, ingestion, and dermal contact may absorb it. You must obtain a permit from the Ontario Ministry of the Environment and Energy each time it is used.

The seedbed or greenhouse must be aired completely after the treatment period. If there is any question, study the safety precautions in the *Pesticides Act*, and follow the manufacturer's directions to the letter.

Unique Characteristics:

Also controls soil insects, nematodes, and fungal diseases.

Manufacturer: *Great Lakes Chemical Corp.*

Common Name: methyl isothiocynate/ dichloropropene

Trade Name: VORLEX PLUS, VORLEX PLUS CP

Chemical Family: Thiocarbamate

Rates of Application:

methyl isothiocynate/ dichloropropene	32.183-258.62 kg/ha
VORLEX PLUS (203g + 373g/L)	56.0-450 L/5.0 L
methyl isothiocynate/ dichloropropene/chloropicrin	40.207- 323.741 kg/ha
VORLEX PLUS CP (185g + 370g/L + 163g/L)	56.0-450 L/5.0 L

Remarks:
A liquid fumigant injected into a prepared seedbed with special applicators. Chloropicrin adds additional disease control. Preplant treatment in field and greenhouse soils used for ornamentals such as flowers and evergreens.

Sensitive Weeds:
All growing weed seedlings within the fumigated zone. Product may not control non–germinated seeds or established weeds.

Basis of Selectivity:
Non–selective. Gas is toxic to most young, green plant tissues.

Application Methods:
Injected 15–20 cm into the soil using special equipment. Seal the soil by surface irrigation or by physically compacting the surface. Cultivate the fumigated soil after the desired waiting period to dissipate the gas.

Residual Activity:
Varies with soil type — usually 4–6 weeks if left undisturbed. Always check the soil for fumigant using the lettuce germination test before planting a crop.

Unique Characteristics:
Also controls fungal diseases and unencysted nematodes.

Manufacturer: *Agrevo*

Preemergence Treatments

Some preemergence treatment chemicals control weeds by killing weed seedlings. Others deposit a toxic chemical layer (in which germinating seeds and young seedlings cannot survive) on or near the soil surface.

- A herbicide may have either or both effects on a target weed.

- Apply pre-emergence treatments either after the seedling stage but before the specified weed or crop emerges, or after planting new nursery stock.

- Crops must tolerate the chemical at the seedling state or the chemical's toxicity must have disappeared before the crop emerges.

- Apply to a smooth, well–prepared, clod–free seedbed for best results.

- The surface soil should be moist and the temperature favourable for rapid weed–seed germination.

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Common Name: chloropropham

Trade Name: **CIPC, CIPC EC, CIPC GR**

Chemical Family: **Phenylcarbamate**

Rates of Application:

chloropropham	6.8-11.0 kg/ha
CIPC	34.0-55.0 kg/ha

Remarks:
Use with field nursery stock or beds, daffodils, gladioli, iris, and tulips.

Sensitive Weeds:
Annual broadleaf and grass weeds including purslane, chickweed, smartweed, carpetweed, false flax, annual blue grass, crabgrass, rye grass, stink grass, and dodder.

Uptake and Translocation:
Readily translocated to leaves following root absorption. Seeds and emerged dodder absorb vapours.

Basis of Selectivity:
Rapid degradation in tolerant plants and from soil adsorption.

Application Methods:
Pre-emergence and directed post–emergence in specified crops. Moist soil required for effective weed control. Use lower application rates on sandy or coarse textured soils, higher rates on clay or muck soils. Soil temperatures below 16° C improve weed control—use lower application rates at low temperatures.

Residual Activity:
Tightly bound to soil colloids. The dissipation rate varies with microbial activity and moisture level. High soil temperature and excessive soil moisture increase the dissipation rate.

Manufacturer: *Stanchem*

Common Name: dichlobenil

Trade Name: CASORON

Chemical Family: Benzonitrile

Rates of Application:

Field applications:

dichlobenil	4.4-7.0 kg/ha
CASORON (4 Gr)	110.0-175.0 kg/ha

Container applications:

dichlobenil	4.4 kg/ha
CASORON (4 Gr)	110.0 kg/ha

Container bed preparation:

dichlobenil	4.4-7.0 kg/ha
CASORON (4 Gr)	110.0-175.0 kg/ha

Remarks:

Use on field woody nursery stock: eastern white cedar (arborvitae), ash, birch (cutleaf weeping), boxwood, caragana, eastern red cedar, crabapple, elm, euonymus, forsythia, heather, holly (*Ilex* sp, except *I. crenata*, *I. rotunda*, *I. vomitoria*), honeysuckle, juniper, lilac, linden, locust, maple, mockorange, rhododendron, rose, spirea, willow, and yew.

Use on some container woody nursery stock: *Juniperus chinensis*, *J. horizontalis*, and *Thuja occidentalis* only.

Do not use on: gladiolus, mugo pine, fir (*Abies* sp), hemlock, ajuga, *Ilex crenata*, *I. rotunda*, *I. vomitoria*, or spruce.

Do not use on: herbaceous perennials (all plants which die down to the ground in the fall).

Use cautiously on: shallow rooted ground covers (euonymus can be treated with this product).

Sensitive Weeds:

Most weeds are susceptible to, or suppressed by, dichlobenil including perennials, vetch, and horsetail.

Uptake and Translocation:

Absorbed by roots and rapidly translocated upward in the plant.

Basis of Selectivity:

Selectivity based on physical separation between the dichlobenil vapour layer in the top 5 cm of soil and the established crop roots below this level.

Application Methods:

Applied as a preemergence treatment to susceptible weeds, preferably in the fall or early spring.

Container nursery stock: Use only on containers growing outside. Apply at least 4 weeks after planting into containers with a weed free surface. Do not use after Sept. 15 or within 30 days of placing treated stock in overwintering structures.

Container bed preparation: Apply to bare soil before putting container pots onto the bed. For best results, apply to soils containing more than 2% organic matter. Inconsistent weed control on gravel or sandy soils. Apply in spring on a cool day and incorporate immediately using irrigation or mechanical methods. Do not cover polyhouses with plastic for 1 month after application. Do not apply in plastic–covered polyhouses or greenhouses. Do not transplant into treated soils for 1 yr.

Residual Activity:

May persist and provide weed control for 2–6 months. Higher rates and applications following use in previous years may cause soil residues to persist for more than 1 yr.

Unique Characteristics:

Although applied as a granular herbicide, it kills with a vapour layer in the topsoil profile. Weed roots take up herbicide when entering this zone. Do not apply to very warm soils, since high temperatures volatilize the herbicide and prevent weed control.

Manufacturer: *Uniroyal Chemicals*

Common Name: napropamide

Trade Name: DEVRINOL 10G,
DEVRINOL 50 DF,
DEVRINOL 50 W

Chemical Family: Amide

Rates of Application:

napropamide	4.5 kg/ha
DEVRINOL 10G (10 Gr)	45.0 kg/ha
DEVRINOL 50DF (50 DF)	9.0 kg/ha
DEVRINOL 50W (50WP)	9.0 kg/ha

DEVRINOL can be tank mixed with SIMAZINE 80 W napropamide (4.5 kg/ha) plus simazine (1.096 kg/ha)

DEVRINOL DF (50 DF) 9.0 kg/ha plus SIMAZINE 80W (80WP) 1.37 kg/ha

Remarks:

Use on: newly–transplanted or established ornamentals, woody nursery stock, forest tree stock, and container–grown ornamentals.

Use on all of the following field–grown nursery stock: maple, boxwood, hawthorn, euonymus, honeylocust, hibiscus, hypericum, holly, juniper, plum, privet, laburnum, apple, spruce, pine, poplar, cherry, peach, pear, firethorn, rhododendron, azalea, rose, and yew.

Use on the following container–grown nursery stock: boxwood, euonymus, English ivy, holly, juniper, privet, pine, firethorn, rhododendron, azalea, rose, and cedar.

Sensitive Weeds:

Many annual weeds including crabgrass, barnyard grass, annual blue grass, foxtail, sandbur, wild oats, goose grass, chickweed, groundsel, redroot pigweed, lamb's quarters, purslane, prostrate knotweed, pineappleweed, and prickly lettuce.

Uptake and Translocation:

Absorbed through the roots of germinating weeds. Translocated upward through seedlings.

Basis of Selectivity:

Metabolized by tolerant species. Inhibits root growth of germinating seedlings. Doesn't affect established plants due to placement selectivity.

Application Methods:

Field nursery stock: Apply herbicide preplant using water as the carrier. Incorporate uniformly to 2.5–5 cm depth, using irrigation or mechanical methods (e.g., tandem discs, field cultivator with sweep teeth). Follow with a leveling device.

Apply on established crops to a weed free soil surface. Irrigate unless there is adequate rainfall within 7 days after spring/fall application or within 2 days after summer application. Soil must be wet to a depth of 5–10 cm.

Container nursery stock: Apply at any time of the year to a weed–free media surface. May be used on newly–planted container stock once potting media settles after first watering. Incorporate by watering within 7 days after a spring or fall application. Water within 2 days after a summer application. Doesn't control bittercress.

Residual Activity:

Provides season long weed control if properly incorporated. Deep plowing minimizes carryover effects.

Unique Characteristics:

Does not control germinated weeds. Resists leaching. Don't plant crops not registered for product use for 12 months after a napropamide application to avoid injury.

Manufacturer: *Zeneca*

Common Name: oxadiazon

Trade Name: **RONSTAR 2G**

Chemical Family: **Oxadiazole**

Rates of Application:

oxadiazon	2.0-4.5 kg/ha
RONSTAR 2G (2 Gr)	100.0-225.0 kg/ha

Remarks:

Use in container nursery stock on: vine maple, dogwood, emerald and gold euonymus, juniper, mugo pine, scotch pine, potentilla, Colorado spruce, Serbian spruce, Nanking cherry, alpine currant, golden elder, lilac.

The following plants are sensitive to RONSTAR 2G: *Andromeda* Snowdrift, Temple Bell; *Cotoneaster* Eichholz, Himalayan, Shangri–la; *Calluna* spring heath Mediterranea pink; *Hibiscus* Red Heart; *Picea abies* Primila, Norway spruce Primila; *Picea glauca* Densena, Densena white spruce; *Rhododendron* Azaleas Pink Champagne, Hershey, Leuchtenfuer, Memoire, John Hearrens, Himo–Crimson, White Grandeur, Everest, Girard Roberta, Rhododendron Daphnoides, Nova Zimbela; *Tsuga canadensis* Pendula, weeping hemlock; *Viburum davidii*, David viburnum.

Sensitive Weeds:

Annual weeds including stinkweed, bittercress, common groundsel, lamb's quarters, purslane, black nightshade, pigweed, redroot, tumble, shepherd's purse, annual blue grass, barnyard grass, green and yellow foxtail, and crabgrass.

Uptake and Translocation:

Primarily through emerging shoots when they penetrate through the treated soil layer.

Basis of Selectivity:

Greater physiological tolerance relative to susceptible species and lack of contact with sensitive crop tissue.

Application Method:

Use on newly–transplanted and established ornamentals and trees. Apply uniformly to soil. Apply at any time of the year before weed seeds germinate. Remove existing weed growth for satisfactory weed control. *Do not apply* to wet foliage or when granules can collect on leaves. Apply the herbicide at least 4 weeks before covering polyhouses in the fall.

Residual Activity:

60–120 days

Unique Characteristics:

Moisture activates the chemical—rainfall or overhead irrigation after application improves weed control. When applied to soil, product is rapidly and strongly fixed by soil colloids. Due to low water solubility and this adsorption, downward and lateral movement is limited under the influence of rain or irrigation.

Manufacturer: *Rhone & Poulenc*

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Common Name: propyzamide

Trade Name: **KERB**

Chemical Family: **Amide**

Rates of Application:

propyzamide	1.5 kg/ha
KERB (50WG)	3.0 kg/ha

Remarks:

Use on coniferous trees and shrubs, established iris, peony, and ground covers. Do not use on *Vinca minor*.

Sensitive Weeds:

Perennial grasses including quackgrass, annual grasses, volunteer cereals, and common chickweed.

Uptake And Translocation:

Taken up by plant roots and translocated to foliage. Little foliar absorption.

Basis of Selectivity:

Faster degradation in tolerant species.

Application Methods:

Preemergence to annual weeds. Post–emergence control of perennial grasses when applied in the fall. Apply from late–Sept. to Nov. when soil temperature is low but above freezing and soil moisture is high.

Residual Activity:

Persists 2–9 months, depending on soil type and climate. Decomposes slowly at temperatures under 1° C, but accelerates at temperatures above this level. Greatest persistence in sandy soils with low organic matter.

Unique Characteristics:

Rainfall or irrigation required after application. This moves herbicide into the root zone for uptake by perennial grasses and germinating annual grasses.

Manufacturer: *Rhom & Haas*

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Common Name: simazine

Trade Name: **PRINCEP NINE-T, SIMADEX, SIMAZINE, SIMAZINE 480**

Chemical Family: **S-triazine**

Rates of Application:

Field applications:	
simazine	2.25-3.38 kg/ha
PRINCEP NINEñT (90WG)	2.50-3.75 kg/ha
simazine	2.20-3.40 kg/ha
SIMAZINE 80W (80 WP)	2.75-4.25 kg/ha
simazine	1.80-6.75 kg/ha
SIMADEX (500 g/L)	3.60-13.50 kg/ha
Container applications:	
simazine	2.25 kg/ha
PRINCEP NINE-T (90WG)	2.50 kg/ha
SIMAZINE 80W (80 WP)	2.80 kg/ha/300 L

Remarks:

Use on new or established Christmas tree and woodland plantations (2 yr. or older white pine and balsam fir). Use *Princep Nine–T* (only) for conifer site preparation before planting fir, pine, and spruce.

Use on woody ornamentals and nursery stock established at least 1 yr.: cedar, barberry, apple, flowering crabapple, boxwood, cotoneaster, dogwood, holly, rose, yews, chamaecyparis, hemlock, juniper, multiflora rose, peony, spruce, mugo pine, black walnut, and white ash.

Use on container nursery stock: *Juniperus, Thuja* and *Taxus* only.

Sensitive Weeds:

Annual broadleaf weeds such as pigweed, lady's thumb, lamb's quarters, purslane, ragweed, volunteer clover, wild buckwheat, smartweed, plantain, and groundsel. Annual grasses such as barnyard grass, crabgrass, wild oats and yellow foxtail. Most perennial species starting freshly from seed. Doesn't control triazine–resistant biotypes of foxtail, lamb's quarters, pigweed, and groundsel.

Uptake and Translocation:

Absorbed by roots, but little or no foliar absorption. Translocated upwards in xylem, accumulating in apical meristem and leaves with napropamide on new plantings of apples, apricots, cherries, plums, peaches, and pears.

Basis of Selectivity:

Some species, such as corn, metabolize simazine. In most crops, selectivity depends on crop–plant roots being deeper than the depth to which simazine leaches.

Application Methods:

Remove any existing weeds from containers before application. Apply once per season, 1 month after planting and before weeds emerge.

Residual Activity:

Persists longer than atrazine. Soil residues may persist for more than 1 season. Don't plant any crop but corn in the treated area for 1 yr. after a simazine application. If you applied more than 2 kg/ha, don't plant rotational crops the following year. Test soils for excess residues if questions exist.

Unique Characteristics:

Apply only once per season. Needs sufficient moisture to activate. Rotate with non–triazine residual herbicides to avoid resistant weeds. Where rainfall causes erosion, soil containing simazine may wash to lower land and injure existing or subsequent crops.

Manufacturer:

PRINCEP NINE–T:	Ciba Geigy
SIMADEX:	Agrevo Canada Inc.
SIMAZINE 80W:	United Agri Products
SIMAZINE 480:	United Agri Products

Chemical Family: s-metolachlor

Trade Name: **DUAL MAGNUM**

Chemical Family: **Acetanilide**

Rates of Application:

s-metolachlor (915g/L)	0.14-1.60 kg/ha
Dual II Magnum	1.25-1.75 L/ha

Remarks:

Use on second yr. or older white spruce, Norway spruce, black spruce, white pine, Jack pine and red pine transplant or seedling stock. Also for use on poplar stoolbeds.

May be applied as a pre-emergent or early post-emergent application to weeds before they pass the 2-leaf stage. For poplar stoolbeds, apply to dormant and flushing stoolbeds.

Apply to soil prior to bud break. DO NOT APPLY DUAL MAGNUM WITHIN 4 WEEKS AFTER BUD BURST OR UNTIL THE NEEDLES HAVE HARDENED.

Sensitive Weeds:

Annual broadleaf weeds and grasses such as American nightshade, eastern black nightshade, smooth crabgrass, hairy crabgrass, barnyard grass, redroot pigweed (supression only), fall panicum, green foxtail, yellow foxtail, giant foxtail, old witchgrass, yellow nutsedge.

Uptake and Translocation:

Absorbed by germinating grasses mainly through shoot just above seed. Absorbed by germinating broadleaf weeds through roots and shoots.

Basis of Selectivity:

Metabolized by tolerant species.

Application Methods:

Early preplant, preplant incorporated and preemergence. Early postemergence on corn (spike to 2-leaf stage of corn). Incorporation equipment should be set to work the soil 10 cm deep with a disc operating at 6–10 km/hr or a vibrating shank cultivator at 10–13 km/hr; one incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application.

Residual Activity:

Activity will normally be maintained for 10–14 weeks.

Unique Characteristics:

The rate required depends on weed pressure (higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Winter cereals may be planted 4–5 months after metolachlor application. Many tank mix combinations are registered on various crops. Do not use on muck soils or coarse-textured soils low in organic matter.

Manufacturer: Novartis

Common Name: trifluralin

Trade Name: BONANZA, RIVAL, TREFLAN

Chemical Family: Dinitroaniline

Rates of Application

trifluralin	0.6-1.15 kg/ha
BONANZA 400EC (400 g/L)	1.5-2.75 L/ha
RIVAL (60 DF)	1.0-1.9 g/ha
TREFLAN (480 g/L)	1.1-2.1 kg/ha

Remarks:

Use with field–grown nursery stock, perennials (except *Ajuga, Vinca* and *Pachysandra*), and established shelter belts.

Sensitive Weeds:

Effective on most annual grasses. Provides good control of pigweed and lamb's quarters, including the triazine–tolerant biotypes of these weeds.

Uptake And Translocation:

No significant trifluralin absorption or translocation in crops. Controls susceptible weeds as they germinate. Doesn't control established weeds.

Basis of Selectivity:

Physiological growth processes associated with seed germination.

Application Methods:

Preplant incorporated. Apply in 100–300 L water/ha. Use a lower rate of the chemical on sandy soils and a greater rate for loam to clay soils. Do not use on highly organic soils (muck, peat, or black sands above 15% organic matter). Incorporate twice in cross directions using a tandem disc (7–10 km/hr) or tine cultivator (10–13 km/hr) set 8–10 cm deep. Incorporate immediately after application if possible. However, you may delay up to 24 hours as per label directions. Incorporate again anytime before planting. Activated upon incorporation — irrigation is not required.

Residual Activity:

Recommended application rates provide season–long weed control. Doesn't injure succeeding crops under normal conditions. Fall–seeded grain crops will grow in soil treated with trifluralin the preceding spring.

Unique Characteristics:

Strongly absorbed to soil particles and shows negligible leaching. Organic matter and clay content influence the application rate. Does not control ragweed, annual nightshades, or mustards. Lady's thumb may escape.

Manufacturer:

BONANZA: United Agri Products
RIVAL: Agrevro
TREFLAN: DowElanco

Post-Emergence Treatments

Post–emergence treatments are applied after crops and weeds emerge.

- Selective chemicals kill weeds with little damage to desirable plants.
- Many post–emergent treatments are non–selective and can damage desirable plants if used carelessly.
- The types of weeds controlled depend on weed susceptibility and crop tolerance to the chemical. You must apply treatments at the correct stage of crop development. Since weed susceptibility is greatest when most weeds are young, early treatments need less herbicide and cause less crop damage.
- Some herbicides may be applied post–emergence to the crop but as pre-emergence treatments to the weeds. For example, you may cultivate a crop, then apply herbicide to weed–free soil to control subsequent germinating weeds.

Common Name: fluazifop-p-butyl

Trade Name: FUSILADE II

Chemical Family: Aryloxyphenoxypropionate

Rates of Application:

Fluazifop-p-butyl	0.075-0.25 kg/ha
FUSILADE II (125 g/L)	0.6-2.00 L/ha

Remarks:

Use for field and container application. Good on non–grassy ornamental plants, shrubs, trees, non–bearing forest and ornamental nursery field stock, and container grown nursery stock. Over the top application can injure some blue junipers (e.g., *Juniperus horizontalis* "Bar Harbour," "Blue Acres," and "Blue Rug").

Cultivars differ in sensitivity to FUSILADE. For example, *J. horizontalis* "Blue Acres" is sensitive while *J. horizontalis* "Plumosa Compacta" is tolerant. Consult the label for tolerant species. *Test samples of each cultivar not specifically listed on the label before using this product.*

Sensitive Weeds:
Annual grass species, volunteer corn, wheat, barley, and quackgrass.

Uptake and Translocation:
Absorbed primarily by leaves. Translocated to roots and rhizomes.

Basis of Selectivity:
Metabolism by tolerant species.

Application Methods:
Post–emergence. Use a directed application in sensitive species to avoid contacting leaves and green tissue. Use higher application rates for quackgrass. Apply to actively growing grasses when annual grasses are in the 2–5 leaf stage and quackgrass is in the 3–5 leaf stage.

Residual Activity:
None.

Unique Characteristics:
Preplant tillage to break up rhizomes improves quackgrass control. Do not cultivate for 5 days after application. Except as noted on the label, apply broadleaf herbicides separately, and at least 3 days after using this product. Product loses some effectiveness when used on stressed plants (e.g., lack of moisture, excessive humidity, low temperature, very low relative humidity). Weeds may regrow by tillering if you apply product to stressed plants. A new flush of weeds may emerge after the first flush is controlled.

Manufacturer: *Zeneca*

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Common Name: glyphosate

Trade Name: **CLEAR-IT 1, CLEAR-IT 2, CLEAR-IT 3, EXPEDITE GRASS & WEED, ROUNDUP**

Chemical Family: **Amino acid**

Rates of Application:

Emerged annual weeds:

glyphosate	0.801-1.245 kg/ha
ROUNDUP (365 g/L)	2.25-3.5 L/ha

Emerged perennial weeds:

glyphosate	1.69-4.27 kg/ha
ROUNDUP (365 g/L)	4.75-12.0 L/ha

Quackgrass & other perennial grasses:

glyphosate	0.89-2.491 kg/ha
ROUNDUP (365 g/L)	2.5-7.0 L/ha

Perennial weeds (Canada thistle, milkweed, bindweed, dogbane, sow thistle):

glyphosate	2.491-4.27 kg/ha
ROUNDUP (365 g/L)	7.0-12.0 L/ha

Remarks:
Apply to actively growing weeds. Spray must not contact leaves or green bark of trees or shrubs.

Crop and/or Non–Crop Registrations:
EXPEDITE GRASS & WEED, ROUNDUP: mowing and directed application in woody nursery stock

Sensitive Weeds:
Annual grasses, perennial weeds (e.g., quackgrass, Canada thistle, sow thistle, field bindweed, milkweed, cattails, nutsedge, poison ivy), brush (e.g., birch, alder, poplar, raspberry, willow and maple).

Uptake and Translocation:
Absorbed through foliage and translocated throughout the plant.

Basis of Selectivity:
Non–selective for agricultural crops. Conifers are tolerant at some stages for unknown reasons.

Application Methods:
Use post–emergence for perennial weed control. Apply at the bud–bloom growth stage to most perennial weeds. Apply to Canada thistle and sow thistle when at least in early flower bud. Apply to milkweed at flower bud. Apply to bindweed at full flower. Treat quackgrass in spring or fall while actively growing with at least 3–4 new leaves on each emerged shoot.

Remove crop refuse in the fall, but do not till before application. Fall or spring tillage before spring application may reduce weed control. Wait at least 3–5 days after application before working the area. For maximum quackgrass control, till before quackgrass turns completely brown.

Glyphosate can be applied with boom equipment, knapsack sprayers, and high volume spray equipment for agricultural and non–crop uses. Use backpack mist blowers *only* for silvicultural site preparation and roadside brush control. Use aerial applications *only* for silvicultural site preparation and conifer release.

You may apply glyphosate with selective equipment to non–crop areas, tree plantings, grapes, and orchards. (See *Wiper Applicators,* page 73.) Regardless of application method, do not allow herbicide to contact green foliage or green bark of crop or other desirable plants. Remove all suckers from the trunks of desirable trees before spraying.

Residual Activity:

None—crops can be planted or seeded directly into treated areas following application. Use other herbicides to control weeds emerging after the application.

Unique Characteristics:

Rainfall within 6 hours after application or heavy frost may reduce control.

Manufacturer:

CLEAR–IT 1, 2, 3: Monsanto
EXPEDITE GRASS & WEED: Monsanto
ROUNDUP: Monsanto

Common Name: paraquat

Trade Name: GRAMOXONE

Chemical Family: Bipyridylium

Rates of Application:

paraquat	0.55-1.10 kg/ha
GRAMOXONE (200g/L)	2.75-5.5 L/ha

Remarks:

Use for emerged annual weeds and to suppress top growth in perennial weeds.

Crop and/or Non–Crop Registrations:

- Stale seedbed technique
- Inter–row directed chemical weeding for established nursery crops
- Chemical mowing weed control in non–crop land

Sensitive Weeds:

Non–selective action affects all green plants.

Uptake and Translocation:

Absorbed by foliage and green bark. Little or no translocation.

Basis of Selectivity:

All green plant tissue is sensitive. Less effective on plants with a very waxy cuticle and linear leaf shape (e.g., nutsedge). Safe on mature (non green) bark of woody plants.

Application Methods:

Post–emergence. Apply when weeds are under 15 cm high. Use as a chemical mower—apply several times a year to actively growing vegetation. Aim spray to avoid leaves and green bark of nursery plants. For spot treatment, use 25 ml in 4 L of water. Only controls emerged weeds. Suppresses perennial weeds. Broadcast if no danger to leaves or bark of desirable plants. Best results when applied on a dull or cloudy day or in the evening.

Residual Activity:

Essentially no residual soil activity. Persists in organic material (e.g., mulches, turf thatch)—do not reseed such areas for 5 days. Perennial weeds may need multiple applications per season.

Unique Characteristics:

Inactivated by adsorption to soil particles. Not available to homeowners. For a domestic registration, see paraquat/diquat.

Manufacturer: *Zeneca*

Herbicides Registered in Ontario

The following pages contain charts listing information about all herbicides registered in Ontario for use on ornamental nursery stock.

A successful weed control program combines both cultural and chemical control.

Table 5-3 lists significant label restrictions of commonly used herbicides. Whenever using a pesticide, review the manufacturer's instructions.

TABLE 5–3. Herbicide Label and Plant Restrictions

Herbicide	Label and Plant Restrictions
Pre Emergent	
CHLORO IPC, chlorpropham	Ornamental nursery stock
BONAZA 400, RIVAL, TREFLAN, trifluralin	Ornamental nursery stock *except* ajuga, myrtle, and pachysandra
Post Emergent	
GRAMOXONE, paraquat	Ornamental nursery stock; avoid contact with foliage
ROUND-UP, gylphosate	Ornamental nursery stock; avoid contact with foliage

TABLE 5–4. Herbicides Registered for use on Woody Plants

		Preemergent						
Botanical Name	English Name	Casoron	Dual Magnum	Devrinol	Fusilade	Kerb	Ronstar	Simazine, Princep
Abies balsamea	Balsam fir	Not				F		F
Abies sp.	Fir	Not			TFC	F		
Acer sp.	Maple	T[1]F		TFC	TFC			
Acer circinatum	Vine maple						C[2]	
Ajuga sp.	Bugleweed	Not						
Betula pendula 'Gracilis'	Cutleaf weeping birch	T[1]F						
Buxus sp.	Boxwood	T[1]F		TFC	TFC			F
Calluna sp.	Heather	T[1]F			TFC			
Caragana sp.	Peashrub	T[1]F			TFC			F
Carpinus sp.	Blue beech				TFC			
Chaenomeles sp.	Flowering quince				TFC			
Chamaecyparis sp.	False cypress							F
Cornus sp.	Dogwood				TFCD		C[2]	F
Cotinus coggygria	Smoke bush				TFC			
Cotoneaster sp.	Cotoneaster				TFC			F
Crataegus sp.	Hawthorn			TFC				
Deutzia sp.	Deutzia							
Erica sp.	Heath	T[1]F						
Euonymus sp.	Euonymus sp.	T[1]F		TFC	TFC			

* Directed spray from bud break to initial growth hardening.
[1] Apply 4 wks after transplanting
[2] Apply 30 days before covering polyhouses; no later than Sept. 30
C Container
D Directed spray only
F Field
Not Labeled restriction
S Seedbed
T Transplant

TABLE 5–4. Herbicides Registered for use on Woody Plants (cont'd)

		Preemergent						
Botanical Name	**English Name**	**Casoron**	**Dual Magnum**	**Devrinol**	**Fusilade**	**Kerb**	**Ronstar**	**Simazine, Princep**
Euonymus fortunei 'Emerald & Gold'	Emerald & Gold euonymus						C^2	
Forsythia sp.	Forsythia	T^{1}F			TFC			
Fraxinus americana	White ash							F
Fraxinus sp.	Ash	T^{1}F			TFC			
Gleditsia sp.	Honeylocust			TF	TFC			
Gleditsia triacanthos	Honeylocust				T			
Hedera sp.	English ivy			C	TFC			
Hibiscus sp.	Rose of Sharon			TF				
Hydrangea sp.	Hydrangea				TFC			
Hypericum sp.	Hypericum			TF				
Ilex sp.	Holly	T^{1}F		TFC	TFC*			F
Juglans nigra	Black walnut							F
Juglans sp.	Walnut							
Juniperus chinensis Pfitzeriana	Pfitzer juniper	T^{1}FC^{1,2}			TFCD	F		
Juniperus sabina	Sabina juniper	T^{1}FC^{1,2}				F		
Juniperus scopulorum	Rocky mountain juniper	T^1				F		
Juniperus sp.	Juniper	T^{1}F		TFC	TFC*	F	C^2	FC
Juniperus virginiana	Eastern red cedar	T^{1}F				F		
Laburnum sp.	Golden chain tree			TF				
Ligustrum sp.	Privet			TFC	TFC			
Liriodendron sp.	Tulip tree							
Lonicera sp.	Honeysuckle	T^{1}F			TFC			
Malus sp.	Flowering crabapple	T^{1}F		TF	TFC			F
Malus sylvestris (non producteur)	Apple (non-fruiting)			TFC			F	
Parthenocissus quinquefolia	Virginia creeper				TFC			
Philadelphus sp.	Mockorange	T^{1}F			TFCD			
Picea abies	Norway spruce	Not				F		F
Picea abies Nidiformis	Nest spruce	Not				F		
Picea glauca	White spruce	Not				F		F
Picea glauca Conica	Dwarf Alberta spruce	Not				F		
Picea marina	Black spruce		TF					

* Directed spray from bud break to initial growth hardening.

[1] Apply 4 wks after transplanting

[2] Apply 30 days before covering polyhouses; no later than Sept. 30

C Container

D Directed spray only

F Field

Not Labeled restriction

S Seedbed

T Transplant

TABLE 5–4. Herbicides Registered for use on Woody Plants (cont'd)

		Preemergent						
Botanical Name	**English Name**	**Casoron**	**Dual Magnum**	**Devrinol**	**Fusilade**	**Kerb**	**Ronstar**	**Simazine, Princep**
Picea omorika	Serbian spruce	Not					C[2]	
Picea pungens	Colorado spruce	Not					C[2]	
Picea pungens Glauca	Blue Colorado spruce	Not				F		F
Picea pungens Glauca Globosa	Globe blue spruce	Not				F		F
Picea rubens	Red spruce	Not				F		F
Picea sp.	Spruce	Not		TF	TFC*	F		
Pieris sp.	Japanese pieris				TFC			
Pinus banksiana	Jackpine		TF					
Pinus mugo	Mugo pine	Not				F	C[2]	F
Pinus nigra	Austrian pine					F		
Pinus resinosa	Red pine		TF					
Pinus sp.	Pine			TFC	TFC	F		
Pinus strobus	White pine 2 year		TF		F		F	
Pinus sylvestris	Scotch pine						C[2]	
Pittosporum sp.	Pittosporum			TF				
Platanus sp.	Planetree				TFC			
Podocarpus sp.	Podocarpus			TFC				
Populus sp.	Poplar		stoolbed	TF				
Potentilla sp.	Cinquefoil				TFC		C[2]	
Prunus sp.	Cherry (non producing)			TF				
Prunus tomentosa	Nanking cherry						C[2]	
Pseudotsuga menzeisii	Douglas fir				TFC*	F		
Pyracantha sp.	Firethorn			TFC	TFC			
Pyrus sp.	Pear (non producing)							
Quercus sp.	Oak							
Rhododendron sp.	Rhododendron, azalea	T[1]F		TFC	TFC			
Ribes sp.	Currant (non producing)				TFC			
Ribes alpinum	Alpine currant						C[2]	
Robinia pseudoacacia	Black locust							
Robinia sp.	Locust	T[1]F						
Rosa multiflora	Multiflora rose							F
Rosa sp.	Rose	T[1]F		TFC	TFC			F
Salix sp.	Willow	T[1]F			TFC			

* Directed spray from bud break to initial growth hardening.

[1] Apply 4 wks after transplanting

[2] Apply 30 days before covering polyhouses; no later than Sept. 30

C Container

D Directed spray only

F Field

Not Labeled restriction

S Seedbed

T Transplant

TABLE 5–4. Herbicides Registered for use on Woody Plants (cont'd)

		Preemergent						
Botanical Name	**English Name**	**Casoron**	**Dual Magnum**	**Devrinol**	**Fusilade**	**Kerb**	**Ronstar**	**Simazine, Princep**
Sambucus sp.	Elderberry				TFC			
Sambucus canadensis Aurea	Golden elderberry						C[2]	
Spiraea sp.	Spirea	T[1]F			TFC			
Symphoricarpos rivularis	Snowberry				TFC			
Syringa sp.	Lilac	Not			TFC		C[2]	
Taxus cuspidata	Japanese yew					F		
Taxus sp.	Yew	T[1]FC[1,2]		TF	TFC[*]	F		FC
Thuja occidentalis	White cedar	T[1]FC[1,2]				F		
Thuja sp.	Cedar	T[1]F		C	TFC	F		FC
Tilia sp.	Linden, basswood	T[1]F			TFC			
Tsuga sp.	Hemlock	Not			TFC[*]			F
Ulmus sp.	Elm	T[1]F			TFC			
Viburnum sp.	Viburnum				TFC			
Weigela sp.	Weigela				TFC			

*	Directed spray from bud break to initial growth hardening.	D	Directed spray only
1	Apply 4 wks after transplanting	F	Field
2	Apply 30 days before covering polyhouses; no later than Sept. 30	Not	Labeled restriction
C	Container	S	Seedbed
		T	Transplant

TABLE 5–5. Weed Susceptibility and Herbicides — Broadleaf Annuals

Broadleaf Annuals	**Casoron**	**Cipc**	**Dual Magnum**	**Devrinol**	**Kerb**	**Ronstar**	**Simazine Princep**	**Trefelan, Rival, Trifluralin**
Bittercress	S					S		
Buckwheat, wild	S						S	MS
Carpetweed		S		S				S
Chickweed, common	S	S		S	S			S
Clover, volunteer							S	
Cocklebur								
False flax		S						
Galinsoga								
Groundsel, common	S			S		S		
Ground cherry								
Jimsonweed								
Knotweed	S							
Knotweed, prostrate				S				S
Kochia								
Lady's thumb							S	
Lamb's quarters	S			S		S	S	S
Mustards	S							
Nightshade, black			MS			S		
Pigweed	S			S		S		S

S = Susceptible MS = Moderately Susceptible T = Tolerant

TABLE 5–5. Weed Susceptibility and Herbicides — Broadleaf Annuals (cont'd)

Broadleaf Annuals	Casoron	Cipc	Dual Magnum	Devrinol	Kerb	Ronstar	Simazine Princep	Trefelan, Rival, Trifluralin
Pigweed, redroot				S			S	
Pineappleweed				S				
Plantain	S							
Prickly lettuce				S				
Purslane	S	S		S		S	S	S
Ragweed, common				MS			S	
Russian thistle								S
Shepherd's purse	S					S		
Smartweed	S	S					S	S
Smartweed, green							S	
Sow thistle, annual	S			S				
Spurge	S							
Stinkweed						S		
Velvetleaf								

S = Susceptible MS = Moderately Susceptible T = Tolerant

TABLE 5–6. Weed Susceptibility and Herbicides — Broadleaf Perennials

Broadleaf Perennials	Casoron	Cipc	Dual Magnum	Devrinol	Fusilade	Kerb	Ronstar	Simazine	Trifluralin	Roundup
Bindweed	T								T	S
Chickweed mouse eared	MS								MS	S
Dandelion	MS			T						MS
Grape, wild	T									MS
Ground ivy (creeping Charlie)	MS									MS
Horsetail	MS	T						T	T	MS
Mallow										MS
Milkweed									T	S
Nutsedge	MS		S	MS	T			T	T	MS
Plantains	MS									S
Poison ivy					S					
Quackgrass	MS	T		T	MS	MS		T	T	
Sow thistle	MS	T				S		T	T	
Stinging nettle					S					
Thistle, Canada	MS	T						T	T	
Toadflax, yellow					S	S				S
Vetches	MS			T				T	T	
Virigia creeper										

S = Susceptible MS = Moderately Susceptible T = Tolerant

TABLE 5–7. Weed Susceptibility and Herbicides — Annual Grasses

Annual Grasses	Casoron	Cipc	Dual Magnum	Devrinol	Fusilade	Garden Weed Preventer	Kerb	Ronstar	Simazine	Trifluralin	Roundup
Barnyard grass			S	S	S	S		S	S	S	
Bluegrass, annual	S	S		S				S		S	S
Brome grass										S	S
Cheat grass										S	
Crab grass	S	S		S	S	S		S	S	S	
Crab grass, large				S							S
Crab grass, smooth			S								
Darnel, Persian					S					S	
Foxtail, giant			S		S	S					
Foxtail, green	S		S	S	S	S		S		S	S
Foxtail, yellow	S		S	S	S	S		S	S	S	
Goose grass				S						S	
Grasses, annual							S				
Johnson grass					S						
Love(stink) grass		S								S	
Oats, wild				S	S		S		S	S	S
Panicum											
Panicum, fall			S	S		S				S	
Proso millet					S						
Rye grass		S		S							
Witchgrass			S								

S = Susceptible MS = Moderately Susceptible T = Tolerant

Appendices

APPENDIX A. Ontario Ministry of Agriculture, Food and Rural Affairs Advisory Staff

Service	Staff	Address	Contact	email
Nursery and Landscape Advisory Services	Jennifer Hobson Nursery Crop Specialist	Horticultural Division, Bovey Building University of Guelph Guelph, ON N1G 2W1	**Tel**: (519) 824-4120, ext. 2671 **Fax**: (519) 767-0755	jhobson @omafra.gov.on.ca
Turfgrass Extension Advisory Services	Pam Charbonneau Turgrass Specialist	The Guelph Turfgrass Institute 328 Victorial Road South Guelph, ON N1H 6H8	**Tel**: (519) 824-4120, ext. 2597 **Fax**: (519) 766-1704	pcharbon @omafra.gov.on.ca
Agriphone Service	For weekly updates on insect and disease problems of woody landscape plants and turgrass, call OMAFRA's Agriphone Service. Available April through October, you can get the information you need 24 hours a day, 7 days a week.		**1-888-290-4441**	
Agrifax Service	Tired of jotting down the weekly agriphone message? Once a week you can receive a printed copy of either or both agriphone reports by fax or email from April through October. There is a subscription fee of $25 for each report per season. Call the number at right for an order form.		**1-888-4-OMAFRA**	

Nursery & Landscape Plant Information: www.gov.on.ca/omafra/english/crops/hort/nursery.html

APPENDIX B. Ontario Ministry of the Environment Pesticides Control Offices

Region/County	Pesticides Officer Address	Telephone/Fax
Central Region Toronto, Halton, Peel, York, Durham	Charles Zubovits 5775 Yonge Street, 8th Floor Toronto, Ontario M2M 4J1	Tel (416) 326-3671 Toll Free 1-800-810-8048 Fax (416) 325-6347
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	Paul McCubbin Linda Dennie Ontario Government Building 119 King Street West, 12th Floor Hamilton, Ontario L8N 3Z9	Tel (905) 521-7667 (905) 521-7658 Fax (905) 521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Townships of Airy, Murchison, Dickens, Lyell and Sabine)	Andrew Morley 133 Dalton Avenue Kingston, Ontario K7L 4X6	Tel (613) 549-4000, x 2684 Fax (613) 548-6908 Toll Free 1-800-267-0974
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth,Simcoe	Doug Morrow Wray Lampman 659 Exeter Road, 2nd Floor London, Ontario N6E 1L3	Tel (519) 873-5047 (519) 873-5048 Fax (519) 873-5000
Northern Region Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Haliburton, Muskoka, Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West	Ray Potvin John Negusanti 199 Larch Street, Suite 1101 Sudbury, Ontario P3E 5P9	Tel (705) 564-3247 (705) 564-3249 Fax (705) 564-4180
Standards Development Branch	Pesticides Section (Mailing Address) 135 St. Clair Avenue West Toronto, Ontario M4V 1P5	Tel (416) 327-5519 Fax (416) 327-2936
Approvals Branch	Pesticides Licensing 250 Davisville Avenue, 3rd Floor Toronto, Ontario M4S 1H2	Tel (416) 440-3584 Toll Free 1-800-461-6290 Fax (416) 440-6973

APPENDIX C. Accredited Soil Testing Laboratories in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.

A & L Canada Laboratories East, Inc.
2136 Jetstream Road
London, Ontario N5V 3P5
Tel (519) 457-2575
Fax (519) 457-2664
web site www.al-labs-can.com
email aginfo@al-labs-can.com
Contact Mr. Greg Patterson
Mr. Ian McLachlin

Accutest Laboratories
146 Colonnade Road, Unit #8
Nepean, Ontario K2E 7Y1
Tel (613) 727-5692
Fax (613) 727-5222
web site www.accutestlabs.com
email phaulena@accutestlabs.com
Contact Mrs. Lorna Wilson
Mr. Peter Haulena

Agri-Food Laboratories
503 Imperial Road, Unit #1
Guelph, Ontario N1H 6T9
Tel (519) 837-1600, 1-800-265-7175
Fax (519) 837-1242
web site: www.agtest.com
email lab@agtest.com
Contact Mr. Dale Cowan
Ms. Nora Wilson

Soil and Nutrient Laboratory
(formerly Analytical Services, Land Resource Science)
University of Guelph
P.O. Box 3650, 95 Stone Road West
Guelph, Ontario N1H 8J7
Tel (519) 767-6226
Fax (519) 767-6240
email vkerslak@lsd.uoguelph.ca

Stratford Agri Analysis Inc.
(A Daco Laboratories Ltd. company)
1131 Erie Street, Box 760
Stratford, Ontario N5A 6W1
Tel (519) 273-4411, 1-800-323-9089
Fax (519) 273-4411
email saa@dacolabs.com
Contact Mr. Dale Peters
Mr. Gary Roberts
Mr. Keith Lemp

APPENDIX D. Other Contacts

Agriculture & Agri-Food Canada Research Centres
Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue
Ottawa, K1A 0C6
Tel (613) 759-1952

Greenhouse and Processing Crops Centre
Harrow N0R 1G0
Tel (519) 738-2251

Southern Crop Protection and Food Research Centre
1391 Sandford Street
London N5V 4T3
Tel (519) 457-1470

Vineland Research Farm
4902 Victoria Avenue North
Vineland L0R 2E0
Tel (905) 562-4113

Delhi Research Farm
Box 186 Schafer Road
Delhi N4B 2W9
Tel (519) 582-1950

Canadian Food Inspection Agency Regional Offices (Plant Protection)
Belleville
345 College Street East
Belleville, K8N 5S7
Tel (613) 969-3333

Brantford
Federal Building, Dalhousie & Queen St., P.O. Box 637
Brantford, N3T 5P9
Tel (519) 751-8157

Hamilton
709 Main Street West, Suite 101
Hamilton, L8S 1A2
Tel (905) 572-4152

London
457 Richmond Street, Suite 404
London, N6A 3E3
Tel (519) 645-4021

Niagara Falls
Mailing address: P.O. Box 35, Niagara Falls, L2E 6S8

Street address: 4551 Zimmerman Avenue
Niagara Falls, L2E 3M5
Tel (905) 357-5981

Ottawa District
3 Observatory Crescent
Building #3 Central, Experimental Farm
Ottawa, K1A 0C9
Tel (613) 759-1571

Toronto
401 Champagne Drive, Unit 1
Downsview, M3J 2C6
Tel (416) 954-1714

Windsor
441 University Avenue West, Suite 208
Windsor, N9A 5P9
Tel (519) 252-7095

University of Guelph
Main Campus
Guelph, N1G 2W1
Tel (519) 824-4120

Alfred College
Alfred, K0B 1A0
Tel (613) 679-2218

Kemptville College
Kemptville, K0G 1J0
Tel (613) 258-8336

Ridgetown College
Ridgetown, N0P 2C0
Tel (519) 674-1500

Department of Plant Agriculture, Kettleby
1125 Woodchopper's Lane, R.R. # 1
Kettleby, L0G 1J0
Tel (905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Road
Simcoe, N3Y 4N5
Tel (519) 426-7127

Department of Plant Agriculture, Vineland
Box 7000, 4890 Victoria Avenue North
Vineland Station, L0R 2E0
Tel (905) 562-4141

Lab Services Division
Pesticide and Trace Contaminants
P.O. Box 3650, 95 Stone Road West
Guelph, N1H 8J7
Tel (519) 767-6200

Pest Diagnostic Clinic
Tel (519) 767-6256

APPENDIX E. Diagnostic Service

Samples for disease diagnosis, insect or weed identification, nematode counts and Verticillium testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Road West
Guelph, Ontario, N1H 8J7
Tel (519) 767-6256
Fax (519) 767-6240
E-mail pdc@lsd.uoguelph.ca

Payment must accompany samples at the time of submission.

Please make cheque payable to the University of Guelph. Additional charges will be invoiced with the final report. VISA and Mastercard are also accepted. Please do not mail cash

Fee Schedule

Procedures	Price/ Sample
Plant Diseases	
Diagnosis not requiring plating	$25.00
Diagnosis requiring plating	$40.00
Turf diagnosis	$50.00
Bacterial identification using Biolog®	$95.00
Detection of virus using Transmission Electron Microscopy	$85.00
Detection of virus using ELISA (turnaround time = 5 working days)	$60.00
Detection of virus using ELISA (RUSH: 24-hour turnaround. Available for samples received Monday through Thursday. Each additional sample is $20.00. ELISA tests not available for all viruses, contact clinic staff for details.)	$120 for 1–6 samples
Weed identification	$40.00
Insects	
Basic identification	$25.00
Identification requiring dissection and/or extensive keys	$40.00
Nematode and Verticillium Counts	**Price/ Sample**
Nematodes extracted from soil (Bearman Pan Method)	$25.00
Nematodes extracted from roots	$60.00
Verticillium count	$60.00
SCN cyst count + egg count	$35.00

A minimum fee of $25.00 should accompany all submissions.

How to Sample for Nematodes

Soil

When to Sample

Soil and root samples can be taken at any time of the year that the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May and June and again in September and October.

How to Sample Soil

Use a soil sampling tube, trowel or narrow-bladed shovel to take samples. Sample soil to a depth of 20–25 cm (8–10 in.). If the soil is bare, remove the top 2 cm (1 in.) prior to sampling. A sample should consist of 10 or more subsamples combined. Mix well. Then take a sample of 1/2–1 L (1 pint–1 quart) from this. No one sample should represent more than 2.5 ha (6.25 ac). Mix subsamples in a clean pail or plastic bag.

Sampling Pattern

If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees, this is the drip line).

Number of Subsamples

Based on the total area sampled:

500 m^2 (5,400 ft^2)	10 subsamples
500 m^2–0.5 ha (5,400 ft^2–1.25 ac)	25 subsamples
0.5 ha–2.5 ha (1.25–6.25 ac)	50 subsamples

Roots

From small plants, sample the entire root system plus adhering soil. For large plants, 10–20 g (1/2–1 oz.) dig fresh weight from the feeder root zone and submit.

Problem Areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take samples from healthy areas in the same field. If possible, take both soil and root samples from problem and healthy areas in the same field.

Sample Handling

Soil Samples

Place in plastic bags as soon as possible after collecting.

Root Samples

Place in plastic bags and cover with moist soil from the sample area.

Storage

Store samples at 5–10°C (40–50°F) and do not expose them to direct sunlight or extreme heat or cold (freezing). **Only living nematodes can be counted. Accurate counts depend on proper handling of samples.**

Submitting Plant for Disease Diagnosis or Identification

Sample Submission Forms

Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. For turfgrass, submit a 10–15 cm^2 piece of turf, including thatch and at least 5 cm of soil. Take the sample from the outside edge of a ring or patch, and include healthy and unhealthy turf, as well as the interface between. If symptoms are general, collect the sample from an area where they are of intermediate severity. **Completely dead material is usually inadequate for diagnosis.**

With plant specimens submitted for identification, include at least a 20–25-cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag to avoid drying out and contamination of the leaves by soil. Do **NOT** add moisture, as this encourages decay in transit. Cushion specimens and pack in a sturdy box to avoid damage during shipping. Avoid leaving specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

Delivery

Deliver to the Pest Diagnostic Clinic as soon as possible by first class mail or by courier at the beginning of the week.

Submitting Insect Specimens for Identification

Collecting Samples

Place dead, hard-bodied insects and spiders in vials or boxes and cushion with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water, as this results in rot. Do not tape insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

APPENDIX F. The Metric System

Metric Units

Linear Measures (length)

10 millimetres (mm)	=	1 centimetre (cm)
100 centimetres (cm)	=	1 metre (m)
1,000 metres	=	1 kilometre (km)

Square Measures (area)

100 m X 100 m = 10,000 m^2	=	1 hectare (ha)
100 ha	=	1 square kilometre (km^2)

Cubic Measures (volume)

Dry Measure

1,000 cubic millimetres (mm^3)	=	1 cubic centimetre (cm^3)
1,000,000 cm^3	=	1 cubic metre (m^3)

Liquid Measure

1,000 millilitres (mL)	=	1 litre (L)
100 L	=	1 hectolitre (hL)

Weight-Volume Equivalents (for water)

(1.00 kg) 1,000 grams	=	1 litre (1.00 L)
(0.50 kg) 500 g	=	500 mL (0.50 L)
(0.10 kg) 100 g	=	100 mL (0.10 L)
(0.01 kg) 10 g	=	10 mL (0.01 L)
(0.001 kg) 1 g	=	1 mL (0.001 L)

Weight Measures

1,000 milligrams (mg)	=	1 gram (g)
1,000 g	=	1 kilogram (kg)
1,000 kg	=	1 tonne (t)
1 mg/kg	=	1 part per million (ppm)

Dry–Liquid Equivalents

1 cm^3	=	1 mL
1 m^3	=	1000 L

Application Rate Conversations

Metric to Imperial (Approximate)

litres per hectare x 0.09	=	gallons per acre
litres per hectare x 0.36	=	quarts per acre
litres per hectare x 0.71	=	pints per acre
millilitres per hectare x 0.015	=	fluid ounces per acre
grams per hectare x 0.015	=	ounces per acre
kilograms per hectare x 0.89	=	pounds per acre
tonnes per hectare x 0.45	=	tons per acre

Imperial to Metric (Approximate)

gallons per acre x 11.23	=	litres per hectare (L/ha)
quarts per acre x 2.8	=	litres per hectare (L/ha)
pints per acre x 1.4	=	litres per hectare (L/ha)
fluid ounces per acre x 70	=	millilitres per hectare (mL/ha)
tons per acre x 2.24	=	tonnes per hectare (t/ha)
pounds per acre x 1.12	=	kilograms per hectare (kg/ha)
ounces per acre x 70	=	grams per hectare (g/ha)

Liquid Equivalents

Litres/Hectare		*Approximate Gallons/Acre*
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

Dry Weight Equivalents

Grams or Kilograms / Hectare		*Ounces or Pounds /Acre*
100 grams	=	1 1/2 ounces
200 grams	=	3 ounces
300 grams	=	4 1/4 ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
1.10 kilograms	=	1 pound
1.50 kilograms	=	1 1/4 pounds
2.00 kilograms	=	1 3/4 pounds
2.50 kilograms	=	2 1/4 pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3 1/2 pounds
5.00 kilograms	=	4 1/2 pounds
6.00 kilograms	=	5 1/4 pounds
7.50 kilograms	=	6 3/4 pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11 1/2 pounds
15.0 kilograms	=	13 1/2 pounds

Metric Conversions

5 mL	=	1 tsp
15 mL	=	1 tbsp
28.5 mL	=	1 fl. oz

Conversion Tables — Metric to Imperial

Length

1 millimetre (mm) = 0.04 inch
1 centimetre (cm) = 0.40 inch
1 metre (m) = 39.40 inches
1 metre (m) = 3.28 feet
1 metre (m) = 1.09 yards
1 kilometre (km) = 0.62 mile

Area

1 square centimetre (cm^2) = 0.16 square inch
1 square metre (m^2) = 10.77 square feet
1 square metre (m$^{2)}$ = 1.20 square yards
1 square kilometre (km^2) = 0.39 square mile
1 hectare (ha) = 107,636 square feet
1 hectare (ha) = 2.5 acres

Volume (dry)

1 cubic centimetre (cm^3) = 0.061 cubic inch
1 cubic metre (m^3) = 1.31 cubic yards
1 cubic metre (m^3) = 35.31 cubic feet
1,000 cubic metres (m^3) = 0.81 acre-foot
1 hectolitre (hL) = 2.8 bushels

Volume (liquid)

1 millilitre (mL) = 0.035 fluid ounce
1 litre (L) = 1.76 pints
1 litre (L) = 0.88 quart
1 litre (L) = 0.22 gallon (Imp.)
1 litre (L) = 0.26 gallon (U.S.)

Weight

1 gram (g) = 0.035 ounce
1 kilogram (kg) = 2.21 pounds
1 tonne (t) = 1.10 short tons
1 tonne (t) = 2,205 pounds

Pressure

1 kilopascal (kPa) = 0.15 pounds/in^2

Speed

1 metre per second = 3.28 feet per second
1 metre per second = 2.24 miles per hour
1 kilometre per hour = 0.62 mile per hour

Temperature

°F = (°C X 9/5) + 32

Conversion Tables — Imperial to Metric

Length

1 inch = 2.54 cm
1 foot = 0.30 m
1 yard = 0.91 m
1 mile = 1.61 km

Area

1 square foot = 0.09 m^2
1 square yard = 0.84 m^2
1 acre = 0.40 ha

Volume (dry)

1 cubic yard = 0.76 m^3
1 bushel = 36.37 L

Volume (liquid)

1 fluid ounce (Imp.) = 28.41 mL
1 pint (Imp.) = 0.57 L
1 gallon (Imp.) = 4.55 L
1 gallon (U.S.) = 3.79 L

Weight

1 ounce = 28.35 g
1 pound = 453.6 g
1 ton = 0.91 tonne

Pressure

1 pound per square inch = 6.90 kPa

Temperature

°C = (°F – 32) x 5/9

Abbreviations

% = per cent (by weight)
ai = active ingredient
AP = agricultural powder
cm = centimetre
cm^2 = square centimetre
DG = dispersible granular
DP = dispersible powder
E = emulsifiable
e.g. = for example
EC = emulsifiable concentrate
F = flowable
g = gram
Gr = granules, granular
ha = hectare
kg = kilogram
km/h = kilometres per hour
kPa = kilopascal
L = litre
m = metre
m/s = metres per second
m^2 = square metre
mL = millilitre
mm = millimetre
SC = sprayable concentrate
SP = soluble powder
t = tonne
W = wettable (powder)
WDG = water dispersible granular
WP = wettable powder
km/h = kilometres per hour

Index

A

A & L Canada Laboratories East: 12
Abiotic diseases: 35
Abies (Fir) pests: 39, 90
Accredited soil testing: 11
Accutest Laboratories: 12
Acer(maple) pests: 13, 34, 39, 90
Aceria erinea (see walnut blister mite)
Acidification of soil: 15
Acidifying fertilizers: 14
Acute oral LD_{50}: 36
Acute toxicity: 2
Adelges abietis
  (see Eastern spruce gall adelgid)
Adelges cooleyi
  (see Cooley spruce gall aphid)
Adelges lariciatus
  (see woolly larch adelgid)
Aeration: 19
Aeration pore volume: 19
Aesculus (Horsechestnut) pests: 41
Agricultural index: 14
Agriculture and Agrifood Canada: 98
Agri-food Laboratories: 12
Agrilus anxium (see bronze birch borer)
AgriMycin (streptomycin sulphate): 37
Agrobacterium tumefaciens
  (see Crown gall)
Agyresthis thuiella (see cedar leaf miner)
Agyrotaenia velutinana
  (see red banded leaf roller)
Air application of pesticides: 7
Ajuga sp. (Bugleweed): 90
Alamo (propiconazole): 37
Alder (see *Alnus*)
Aliphatic nitrogenous compound (An): 36
Allanthus ceitus (see rose slug)
Alnus (Alder) pests: 41
Alsophila pometaria
  (see fall cankerworm)
Ambush: 37
Amelanchier (serviceberry) pests:
  ...... 29-30, 34
Amitrole-T: 69
Ammonia fatty acid soaps: 67
Ammonium nitrate: 14, 22
Ammonium sulphate: 14
Anhydrous ammonia: 14
Anisota senatoria
  (see orange striped oakworm)
Annual blue grass: 82, 83, 84, 95
Anthracnose: 32
  • on *Aesculus*: 41
  • on *Catalpa*: 32
  • on *Euonymus*: 44
  • on *Fraxinus*: 45
  • on *Ligustrum*: 48
  • on *Platanus*: 55
  • on *Quercus*: 58
Anti-coagulant bait: 66-67
Aphids: 24, 25, 26
  • on *Abies*: 39
  • on *Acer*: 39
  • on *Betula*: 41
  • on *Carya*: 42
  • on *Fagus*: 44
  • on *Larch*: 47
  • on *Liriodendron*: 48
  • on *Lonicera*: 48
  • on *Malus*: 49
  • on *Picea*: 29, 31, 50
  • on *Pinus*: 52
  • on *Prunus*: 56
  • on *Rosa*: 59
  • on *Salix*: 60
Aphrophora cibrata (see pine spittle bug)
Apiogominia veneta
  (Sycamore anthracnose): 55
Apiosporina morbosa
  (Black knot on *Prunus*): 56
APM (azinphos-methyl,
  Guthion, Sniper): 37
Apple (see *Malus*)
Apple and thorn skeletonizer
  (*Choreutis pariana*): 30, 31
Apple scab (*Venturia inaequalis*): 33, 50
Application indicators: 79
Application rates: 76
Application Technology: 73
April insects: 29
Arborvitae (see *Thuja*)
Archips argyrospilus
  (see fruit tree lecanium)
Archips cerasworanus
  (see uglinest caterpillar)
Armoured scales: 27
Aromatic hydrocarbon (Arom): 36, 37
Aronia (chockeberry) pests: 33
Ash (see *Fraxinus*)
Ash borer (*Pososesia syringae*): 44
Ash flower gall mite (*Eriophyes
  fraxiniflora*): 29, 44
Ash plant bug (*Tropidosteptes
  amoenus*): 45
Ash yellows: 35
Asterolecanium variolosum
  (see golden oak scale)
Azalea (see *Rhododendron*)
Azinphos-methyl
  (Guthion, Sniper, APM): 37

B

Bacillus thuringiensis
  (Dipel, Foray, Thuricide): 37
Bacteria blight
  (*Pseudomonas syringae*)
  • on *Forsythia*: 44
Bacterial canker
  (*Pseudomonas syringae*)
  • on *Prunus*: 56
  • on *Rosa*: 60
  • on *Syringa*: 62
Bait stations: 66
Balsam twig aphid
  (*Mindarus abientiunus*): 39
Barnyard grass: 95
Basamid (see dazomet)
Bas-oil Red: 79
Bee poisoning: 8
Beech blight aphid
  (*Fagiphagus imbricator*): 44
Beetles: 24, 25, 27
  • Japanese beetle: 27-28, 30, 31, 59
  • Rose chafer: 30, 59
Benzimidazole (Ben): 37
Betula (birch) pests: 41, 90
Bindweed: 94
Bipyridulium: 89
Birch leaf miner
  (*Fenusa pusilla*): 29, 30, 41
Birch skeletonizer
  (*Bucculatrix canadensisella*): . 30, 41
Bittercress: 93
Black knot on *Prunus*
  (*Apiosporina morbosa*): 56
Black sooty mold: 26
Black spot on Rose
  (*Diplocarpon rosae*): 60
Black vine weevil (*Otiorhynchus
  sulcatus*): 30, 62
Black locust (see *Robinia*)
Blazon blue: 79
Blight (see Bacterial Blight, Blossom
  blight or Leaf Blight)
Blood tests: 3
Bloodmeal: 68
Blossom and twig blight on *Prunus*
  (*Monilina fucticola*): 56
Blue beech (see Carpinus)
Blumeriella jaapii
  (Shothole leaf spot): 56
Bonanza (see trifluralin)
Boomtype sprayer: 73
Bordeaux Mixture: 37
Borers: 27
  • on *Acer*: 40
  • on *Betula*: 29, 41
  • on *Fraxinus*: 44
  • on *Populus* and *Salix*: 30-31, 55
Boron: 12
Botran: 37
Botrytis: 32, 46, 60, 63
(*Botrytis cinerea*, Grey mold)
Boxwood (see *Buxus*)
Boxwood leaf miner
  (*Monarthropalpus buxi)* 42
Boxwood psyllid (*Psylla buxi*): 42
Broad leaf annual and perennials
  weeds: 93-95
Broadcast nozzle tips: 75
Broadifacaum: 67
Brome grass: 95
Bronze birch borer
  (*Agrilus anxium*): 29, 41
Brown spot on pine (*Scirrhia* sp.): 55
Bryobia praetiosa (see clover mite)
Bucculatrix ainsiella
  (see oak skeletonizer)
Bucculatrix candensisella
  (see Birch skeletonizer)

Buckeye (see *Aesculus*)
Buckwheat, wild: 93
Buffer pH testing: 14
Bugleweed (see *Ajuga*)
Bullsey Basal 55 Blue: 79
Butternut canker (*Sirococcus clavigignenti-juglandacearum*): 33, 46
Buxus (Boxwood) pests: 42, 90

C

Calaphis betulaecolens (see aphids on *Betula*)
Calcitic limestone: 14
Caliroa cerasi (Pear sawfly or pearslug): 30, 56
Calluna sp. (heather): 90
Canada thistle: 94
Canister gas masks: 5
Cankers: 33
  - on *Buxus*: 42
  - on *Juglans*: 33, 46
  - on *Picea*: 51

Captan: 37
Caragana sp. (peashrub): 90
Carbaryl (Sevin): 37
Carpet weed: 93
Carpinus (blue beech): 90
Carulaspis juniperi (see juniper scale)
Carya (Hickory) pests: 42
Casebearers: 25
  - on *Larix*: 47

Casoron (see dicholbenil)
Catalpa pests: 42
Caterpillars: 25
  - fall cankerworm: 29, 49, 57, 64
  - fall webworm: 31, 45
  - forest tent caterpillar: 29, 40
  - orange-striped oakworm: 58
  - spring cankerworm: 29, 49, 57, 64
  - spruce budworm: 39
  - walnut caterpillar: 46

Caloptilia syringella (see lilac leaf miner)
Caulocampis acericaulis (see maple petiole borer)
Canadian Food Inspection Agency: 98
Cedar (see *Thuja*)
Cedar apple rust (*Gymnosporangium juniperi-virginianae*): 47, 50
Cedar leafminer (*Agyresthis thuiella*): 29, 30, 63
Ceratocystis (Ophiostoma) ulmi (Dutch elm disease): 34, 65
Chaenomeles (Flowering quince) pests: 30, 31, 33, 42, 90
Chamaecyparis (False cypress): 90
Cheatgrass: 95
Chemical families: 36
Chemical repellants: 67
Cherry (see *Prunus*)
Chestnut blight: 33
Chickweed: 93, 94
Chionospis pinifoliae (see pine needle scale)
Chloropicrin: 5, 79
Chloropropham (CIPC, CIPC EC, CIPC GR): 79, 82
Chlorothalonil (Daconil 2787): 37
Chlorphacinone: 67
Chlorpyrifos (Dursban, Pyrate): 37
Clover mite (*Bryobia paetiosa*): 26
Choristoneura fumiferana (see spruce budworm)
Chronic toxicity: 2
Cicadas: 25
Cinara strobi (see white pine aphid)
CIPC, CIPC EC, CIPC GR (see chloropropham)
Cladrastus (yellowwood): 34
Clean Pak: 9
Clear wing moth: 25 (also see pine pitch mass borer, lilac borer, peach tree borer)
Clear-it 1,2,3 (see glyphosate)
Clover: 69, 93
Clover mite (*Bryobia praetiosa*): 26
Cocklebur: 93
Coleophora laricella (see larch casebearer)
Coleophora limosipennella (see elm casebearer)
Composted bark: 19
Comptonia peregrina (sweet fern): 55
Conductivity (soil): 15
Conifers
  - Sampling leaf tissue 13
  - Leaf tissue nutrients: 13

Container beds: 70
Container disposal: 7
Container grown crop nutrient levels: 22
Container soils testing and sampling: 21
Contaminated material disposal: 7
Contarinia juniperina (see juniper midge)
Controlled release fertilizers: 21
Conversion Tables: 101
Cooley spruce gall aphid (*Adelges cooleyi*): 29, 31, 50
Copper: 11, 12, 37
Copper oxychloride (Copper spray): 37
Copper spray (copper oxychloride): 37
Cork tree (see *Philodendron*)
Cornus (Dogwood) pests: 29, 30, 34, 43, 90
Cotinus sp. (smoke bush): 34, 90
Cotoneaster: 29, 30, 33, 90
Cottony maple scale (*Pulvinaria innumerablilis*): 29, 39
Cover crops: 69, 80
Crabapple (see *Malus*)
Crabgrass: 95
Crataeagus (Hawthorn) pests: 29, 30, 31, 43, 90
Crimson erineum mite (*Eriophyes regulus*): 29, 40
Croesia semipurpurana (see oak leaftier)
Cronartium comptonia (sweet feern blister rust): 55
Cronartium ribicola (white pine blister rust): 55
Crop rotation: 69, 71
Crown gall (*Agrobacterium tumefaciens*): 34, 44
Crown rots: 33
Cryptorynchus lapathi (see poplar and willow borer)
Cultivation: 71
Currant (see *Ribes*)
Cygon (dimethoate): 37
Cymbush (Ripcord, cypermethrin): 9, 37
Cypermethrin (Cymbush, Ripcord): 9, 37
Cyprex (dodine): 37
Cytospora (*Valsa*, branch dieback on spruce): 51

D

Daconil (chorothalonil) 37
Damping off: 33
Dandelion: 94
Danex (trichlorfon): 37
Darnel, Persian: 95
Daphne (daphne): 34
Dasyneura gleditschiae (see honeylocust podgall midge)
Datana integerrima (see walnut caterpillar)
Dazomet (Basamid): 80
Deer control: 67
Defoliators: 25
Dendrothrips ornatus (see Privet thrips)
Dermal LD_{50}: 36
Deutzia: 29, 30, 90
Devrinol (see napropamide)
Diaphnocoris chlorionis (see honeylocust plant bug)
Diazinon (DZN): 37
Dicarboximide (Dicarb): 36
Dichloran (botran): 37
Dichloropropene (Vorlex): 79, 81
Dichomeris marginella (see juniper webworm)
Dicholbenil (Casoron): 79, 83
Didymascella/Keithia (leaf blight on *Thuja*): 63
Dieback: 35
Dinitrophenol (Dinitro): 36
Dioryctria zimmermani (see Zimmerman pine moth)
Dipel (*Bacillus thuringiensis*): 37
Diphacinone: 67
Diplocarpon sp. (leaf blight on *Crataeagus*): 43
Diplocarpon rosae (black spot on *Rosa*): 60
Diplodia pinea / Sphaeropsis sapinea (Diplodia tip blight on *Pinus*): 54
Diplodia tip blight (*Diplodia pinea/ Sphaeropsis papinea*): 54
Disulfoton (Disyston): 37
Disyston (see disulfoton)
Dithane DG (mancozeb): 37
Dithane m-45 (mancozeb): 37
Dithane z-78 (Zineb): 37
Dithiocarbamate (Dithio): 36
Dodine (Cyprex): 37
Dogwood (see *Cornus*)
Downy mildew: 2
Drift (pesticide): 7, 72
Dry flowable pesticides: 9
Dry fomulations: 78
Dursban (chlorpyrifos): 37
Dursban Turf Insecticide: 28
Dusts: 8
Dutch elm disease (*Ceratocystis/ Ophiostoma ulmi*): 34, 65
Dygall: 37
Dylox (trichlorfon): 37
DZN 600 (diazinon): 37

E

Easout (thiophanate methyl): 37
Eastern hemlock looper (*Lambdina fiscelleria*): 64
Eastern spruce gall adelgid (*Adelgis abietis*): 29, 50
Eastern pine shoot moth: 29, 52
Eastern tent caterpillar (*Malacosoma americanum*): 29, 49
Elaphidionoides villosus (see oak twig pruner)
Elderberry (see *Sambucus*)
Eleagnus (Russian olive): 34
Electronic rate controllers: 73
Elm (see *Ulmus*)
Elm bark beetle (native) (*Hylurgopinus rufipes*): 64
Elm case bearer (*Coleophora limosipennella*): 64
Elm leaf beetle (*Pyrrhalta luteola*): 65
Elm leaf miner (*Fenusa ulmi*): 65
Elm yellows: 35
Emulsifiable concentrate mix: 74
Endelomyia aethips (see Rose slug)
Endosulfan (endosulfan, Thiodan): 37,38
English Ivy (see *Hedera*)
Entering treated areas: 3
Eontenranychus multidigituli (see honeylocust spider mite)
Epinotia aceriella (see maple trumpet skeletonizer)
Ergosterol biosynthesis inhibitor (EBI): 36
Erica sp. (heath): 90
Eriophyes fraxiniflora (see ash flower gall mite)
Eriophyes pyri (see pear leaf blister mite)
Eriophyes regulus (see *Crimson erineum mite*)
Eriophyid mites: 24
Erranis tiliariaa (see Linden looper)
Erwinia sp. (Fireblight): 33, 50
Euceraphis punctipennis (see aphids on *Betula*): 83
Euonymus pests: 29, 30, 43, 90
Euonymus anthracnose (*Glomerella cingulata*): 44
Euonymus scale (*Unaspis euonymi*): 29, 30, 43
Euonymus webworm (*Yponomeuta cognatella*): 30, 43
(*Scolytis multistriatus*): 64
European elm scale (*Gossyparia spuria*): 65
European fruit lecanium (*Lecanium corni*): 30, 40
European pine sawfly (*Neodipron sertifier*): 29, 30, 53
European pine shoot moth (*Ryacionia buoliana*): 29, 30, 52
European red mite (*Panononchusulmi*): 26, 29, 61
Expedite Grass and Weed (see glyphosate)
Exposure: 4

F

Fagiphagus imbricator (see beech blight aphid)
Fagus (Beech) pests: 29, 30, 44
Fall cankerworm (*Alsophila pometaria*): 29, 49, 57, 64
Fall fertilization: 18
Fall needle drop of conifers: 35
Fall webworm (*Hyphantria cunea*): 31,45
False cypress (see *Chamaecyparis*)
False flax: 93
Fenusa pusilla (see birch leafminer)
Fenusa ulmi (see elm leafminer)
Ferbam (ferbam): 37
Fertilizer
- Acidifying: 14
- Application rates: 16–18
- Calculations: 21
- Container stock: 20
- Controlled release: 21
- Established field stock: 17
- Fall application: 17
- Field nursery stock: 16
- Landscape plants: 22
- Seed beds: 17
- Spring application: 17
- Transplant liner beds: 17
- Water soluble: 21
- Water soluble packaging: 9

Fir (see *Abies*)
Fire blight (*Erwinia* sp.): 33, 50
Fletcher scale (*Lecanium fletcheri*): 29, 62
Fluazifop-p-butyl (Fusilade II): 87
Foam markers: 79
Foliage diseases: 32
Foliar analysis (plant tissue testing): 13
Foliar nutrient content of nursery stock: 13
Folpan (folpet): 37
Foray (*Bacillus thuringiensis*): 37
Forest tent caterpillar (*Malacosoma disstra*): 29, 40
Forsythia (forsythia) pests: 44, 90
Foxtail: 95
Fraxinus (ash) pests: 29, 30, 34, 35, 44, 90
Fruit tree leafroller (*Archips argyrospilus*): 49, 56
Fumigants: 5, 28, 80-82
Fungicides: 36, 37-38
Funginex: 37
Fusarium: 33
Fusilade II (see fluazifop-p-butyl)

G

Galinsoga: 93
Galls: 24,27
- Ash flower gall mite 29, 44
- Cooley spruce gall adelgid: 29, 50
- Eastern spruce gall adelgid: 29, 50
- Hickory gall aphid: 42
- Honelylocust podgall midge: 29, 45
- Maple bladder gall mite: 29, 40
- Maple spindle gall mite: 29, 40
- Oak leaf gall: 57

Gas masks: 5
Gleditsia (honeylocust) pests: 26, 29, 45, 90
Gloesporium aridum (anthracnose on ash): 45
Glomerella sp. (anthracnose) 44, 48
Glycobius speciosus (sugar maple borer): 40
Glyphosate (Round up, Expedite Grass and Weed, Touchdown): 88
Gnomonia plantani (Sycamore anthracnose): 32
Golden chain tree (see *Laburnum*)
Golden oak scale (*Asterolecanium variolosum*): 57
Golden raintree (see *Koelreutria* sp.)
Golden rod (see *Solidago*)
Goose grass: 95
Gooseberry (see *Ribes*)
Gossyparia spuria (see European elm scale)
Gramoxone (see paraquat)
Grape vine (see *Vitis*)
Grasshoppers: 24
Green manure: 69
Green striped mapleworm (*Dryocampa rubicunda*): 40
Grey mold (See *Botrytis cinerea*)
Ground ivy: 94
Groundsel: 93
Grubs: 27, 35
Guthion (Sniper, azinphos-methyl): 37
Gymnocladus sp. (Kentucky coffee tree): 34
Gymnosporangium sp: 43, 47, 50
Gymnosporangium clavipes (Quince rust): 43, 47
Gymnosporangium globosum (Hawthorn rust): 43, 47
Gymnosporangium juniperi-virginianae (cedar-apple rust): 47, 50
Gypsy moth (*Lymantria dispar*): 29, 41

H

Hand held sprayer (calibration): 77
Hamamelistes spinosus (see aphids on *Betula*)
Hawthorn (see *Crataeagus*)
Hawthorn leafminer (*Profensua collaris*): 43
Heath (see *Erica*)
Heather (see *Calluna*)
Hedera sp. (English ivy) pests: 29, 30, 90
Hederodera glycines (see soybean cyst nematode)
Hemlock (see *Tsuga*)
Heterodera glycines (see Soybean cyst nematodes)
Herbicides:
- Application: 72-95
- Application indicators: 79
- Calibration: 76
- Calculations: 76-78
- Drift: 72
- Dry formulations: 78
- Equipment: 73-76, 79
- Non selective: 72, 79

- Nozzles: 74
- Pre-emergent: 82, 90
- Pre-planting : 79
- Preparation: 74
- Post emergent: 87
- Resistance: 71
- Rotation: 71
- Selective: 72
- Sprayers: 73, 75
- Types: 79-95
- Woody plants: 90-95

Hibiscus sp. (Rose of Sharon) pests: 34
Hickory (see *Carya*)
Hickory gall aphid (*Phylloxera caryaecanlis*): 42
High acute toxicity: 2
Hinder (ammonia fatty acid soap): 67-68
Holly (see *Ilex*)
Honeydew: 26, 27, 39, 51, 54
Honeylocust leafhopper (*Macropsis fumipennis*): 29, 46
Honeylocust mite (*Eotenranychus multidigituli*): 26, 45
Honeylocust plant bug (*Diaphriocoris chlorionis*): 29, 45
Honelylocust podgall midge (*Dasyneura gleditschiae*): 29, 45
Honeylocust (see *Gleditsia*)
Honeysuckle (see *Lonicera*)
Honeysuckle aphid (*Hydaphis tataricae*): 48
Horsechestnut (see *Aesculus*)
Horsechestnut anthracnose (*Glomerella cingulata*): 41
Horsechestnut leafblotch (*Guignaradia aesculi*): 41
Horsetail: 94
Human hair (as a repellent): 68
Hydaphis tataricae (see honeysuckle aphid)
Hydrangea (hydrangea) pests: 46, 90
Hylobius pales (see Pales weevil)
Hylobius radicis (see pine root collar weevil)
Hylurgopinus rufipes (see native elm bark beetle)
Hypericum sp: 90
Hyphantria cunea (see fall webworm)

I

Ilex (holly): 90
Imidan (phosmet): 37
Imported willow leaf beetle (*Plagiodera versicolora*): 29, 30, 60
Insect Pest Classifcation: 24
Insecticides: 37-38
- Band spraying: 7
- Bee poisoning: 8
- Chemical families: 36
- Toxicity: 36

Insecticide smokes: 5
Iron: 12,13

J

Japanese Beetles (*Popillia japonica*): 27, 30, 31, 59
Japanese pieris (see *Pieris*)
Jimson weed: 93
Johnson grass: 95
Juglans (black walnut, butternut) pests: 33, 46, 90
Juniper (see Juniperus)
Juniper tip gall midge (*Rhopalicus* sp.): 47
Juniper midge (*Contarinia juniperina*): 46
Juniper scale (*Carulaspis juniperi*): 30, 46, 63
Juniper webworm (*Dichomeris marginella*): 29, 47
Juniperus (juniper) pests: 29, 30, 46, 63, 90

K

Kabatina juniperi (*Phomopsis juniperovora*, Juniper blight): 47
Kelthane: 37
Kentucky coffee tree (see *Gymnocladus*)
Kerb (see propyzamide)
Knotweed: 93
Kochia: 93
Koelreutria (golden rain tree): 34

L

Laboratories: 12
Laburnum sp. (Golden chain tree): 90
Lacebugs: 45
Lacewings: 39, 41
Lady bugs: 39, 41
Lady's thumb: 93
Lagon: 37
Laidlaw Environmental Management: 7
Lamb's quarters: 93
Lannate (methomyl): 37
Larch casebearer (*Coleophora laricella*): 47
Larch sawfly (*Pristiphora erichsonii*): 30, 47
Larix (Larch, Tamarack) pests: 30, 47
Leafhoppers: 24, 25, 26
- on *Gleditsia*: 46
- on *Malus*: 49
- on *Rosa*: 59
- on *Ulmus*: 65

Leaf blight:
- on *Crataeagus*: 43
- on *Juniperus*: 47
- on *Lonicera*: 48
- on *Pinus*: 54
- on *Prunus*: 56
- on *Salix*: 60
- on *Thuja*: 63

Leaf blotch (on *Aesculus*): 41
Leafminer: 25
- on *Betula*: 29, 30, 41
- on *Buxus*: 42
- on *Syringa*: 29, 30, 61
- on *Thuja*: 29, 30, 63

Leaf rust (*Gymnosporangium* sp.): 33, 43, 50
Leaf scorch (*Acer*): 40
Leaf spot: 32
- on *Acer*: 40
- on *Carya*: 42
- on *Catalpa*: 42
- on *Crataeagus*: 43
- on *Cornus*: 43
- on *Fraxinus*: 45
- on *Ligustrum*: 48
- on *Pinus*: 55
- on *Populus*: 55

Lecanium scale (*Lecanium corni*): 29, 40, 65
Lepidosaphes ulmi (see Oystershell scale)
Lesser peach tree borer (*Synanthedon pictipes*): 56
Lethal dose (LD_{50}): 2, 36
Ligustrum (privet) pests: 29, 30, 34, 47, 90
Lilac borer (*Podesia syringae var. syringae*): 61
Lilac leaf miner (*Caloptilia syringella*): 29, 30, 61
Limestone quality: 14
Linden (see *Tilia*)
Linden looper (*Erannis tiliaria*): 29, 64
Liriodendron (Tuliptree) pests: 13, 48, 90
Locust borer (*Megacyllene robiniae*): 31, 59
Locust leaf miner (*Odontota dorsalis*): 59
Lonicera (honeysuckle) pests: 26, 29, 34, 48, 90
Loopers: 25
- hemlock looper: 64
- linden looper: 29, 64

Lophodermium needle cast (*Lophodermium seditiosum*): 54
Lovegrass: 95
Low acute toxicity: 3
Lygus lineolaris (see tarnish plant bug)
Lymantria dispar (see Gypsy moth)

M

Macrodactylus subspinosus (see rose chafer)
Macropsis fumipennis (see leafhopper)
Macrosphiphum liriodendron (see tulitree aphid)
Magnolia scale (*Neolecanium cornuparvum*): 48
Magnolia (magnolia) pests: 34, 48
Malacomosa americanum (see Eastern tent caterpillar)
Malacomosa disstria (see forest tent caterpillar)
Malathion: 37
Mallow: 95
Malus (apple) pests: 29,30, 31, 33, 49, 90
Mancozeb (Dithane m-45): 37
Manganese: 12, 13
Manure: 16
Manzate: 37
Maple (see *Acer*)
Maple bladder gall mite (*Vasates quadipedes*): 29, 40

Maple petiole borer (*Caulocampis acericaulis*): 40
Maple spindle gall mite (*Vasates aceris-crummena*): 29, 40
Maple trumpet skeletonizer (*Epinotia aceriella*): 40
Meadow voles (see voles)
Mealybugs: 27
- Taxus mealybug: 62

Media porosity: 39-40
Megacyllene robiniae (see locust borer)
Meltatox: 37
Metam sodium (Vapam) 28, 79, 80
Methomyl (Lannate): 37
Methoxychlor: 37
Methyl bromide: 5, 6, 28, 81
Methyl bromide/chloropicrin (Terr-O-Gas): 81
Methyl isothiocyanante/dichloropropene (Vorlex Plus): 81
Metric Units: 101
Mice (see voles)
Micronutrients: 12, 13
Microsphaera sparsa (Powdery mildew on Viburnum): 65
Midges: 27
Milkweed: 94
Mindarus abientinus (see Balsam twig aphid)
Ministry of Environment and Energy: 72
Mist sprayer: 73
Mites: 26, 27, 35
- Ash flower gall mite (on *Fraxinus*): 29, 44
- Clover mite (on *Lonicera, Ulmus*): 26
- Crimson erineum mite (on *Acer*): 29, 40
- European red mite (on fruit trees): 26, 29, 61
- Honylocust mite (on *Gleditsia*): 26, 45
- Maple bladder gall mite (on *Acer*): 29, 40
- Maple spindle gall mite (on *Acer*): 29, 40
- Oak red mite (on *Quercus*): 26, 58
- Pearleaf blister mite (on *Pyrus*): 29, 30, 61
- Rust mite (on *Acer, Gleditsia, Ligustrum, Quercus, Ulmus*): 26, 46
- Spruce spider mite (on *Juniperus, Picea, Thuja, Tsuga*): 26, 29, 30, 47, 51, 63
- Two spotted spider mite (on *Rosa, Tilia, Ulmus*, fruit trees): 25, 30, 49, 59

Miticides: 37
Mock orange (see *Philadelphus*)
Moderate acute toxicity: 2
Molybdenum: 12
Monarthropalpus buxi (see boxwood leafminer)
Monilinia fructicola (Blossom and twig blight on *Prunus*): 56
Monoammonium phosphate: 14
Morphactin (Morph): 36
Morsetan: 37
Moth flakes: 68
Moths: 24, 25, 26
- Birch skeletonizer: 30, 41
- Fall webworm: 31, 45
- Forest tent caterpillar: 29, 40
- Green striped mapleworm: 40
- Gypsy moth: 29, 41
- Linden looper: 29, 64
- Maple trumpet skeletonizer: 40
- Spiny elm caterpillar: 30
- Spruce budworm: 39

Mountain ash sawfly (*Pristiphora geniculata*): 30, 31, 61
Mourning cloak butterfly: 60
Mowing for weed control: 71
Mustards: 93
Mycosphaerella sp. (Leaf spot on ash): 45
Myrica gale (sweet gale): 55

N

Napropamide (Devrinol): 83
Native elm bark beetle (*Hylurgopinus rufipes):* 64
Natural predators: 66, 67
Nectria sp: 33
Needle borwning on conifers: 35
Needlecast: 32
- on *Abies*: 39
- on *Picea*: 52
- on *Pinus*: 54

Nematicides: 28
Nematodes: 28, 79-80
- Root lesion nematode (*Pratylenchus* sp.): 79
- Soybean cyst nematode (*Hederodera glycines*): 28

Neodiprion lecontei (see redheaded pine sawfly)
Neolecanium cornuparvum (see magnolia scale)
Nightshade: 93
Nitric acid: 20
Nitrogen equivalency table: 18
Non-selective herbicides: 80-82, 88, 89
Northern pine weevil (*Pissoides approximatus*): 52
Nozzles: 74
Nutrient adjustment guidelines (manure types): 16
Nutsedge: 94
Nymphalis antiopa (see spiny elm caterpillar)

O

Oak (see *Quercus*)
Oak leaf gall: 57
Oak leaf miner (*Profensa lucifex*): 57
Oak leaftier (*Croesia semipurpurana*): 58
Oak red mite (*Oligonychus bicolor*): 26, 58
Oak skeletonizer (*Buccalatrix ansiella*): 30, 31, 58
Oak twig pruner (*Elaphidionoides villosus*): 58
Odontata dorsalis (see locust leafminer)
Oil mix (herbicides): 74
Oilseed radish: 69
Oligonychus bicolor (see oak red mite)
Oligonychus ununguis (see spruce spider mite)
Ontario Insect Calendar: 29
Ophiostoma (Ceratocystis) ulmi (Dutch elm disease): 34, 65
Orangestriped oakworm (*Anisota senatoria*): 58
Organatin (Org): 36
Organochloride (OC): 36
Organophosphate pesticides: 3, 8
Organophosphorous (OP): 36
Orthene: 37
Otiorhynchus ovatus (see strawberry root weevil)
Otiorhynchus sulcatus (see black vine weevil)
Oxadiazon (Ronstar): 84
Oxithin (OX): 36
Oystershell scale (*Lepidosaphes ulmi*): 29, 30, 45, 49

P

Pachysandra sp. (pachysandra): 29, 30, 43
Paleacrita vernata (see spring cankerworm)
Pales weevil (*Hylobius pales*): 52
Panicum: 95
Panonychus ulmi (see European red mite)
Paraquat (Gramoxone): 89
Parathion: 3
Parthenocissus quinquefolia (Virginia creeper): 94
Peach (see *Prunus*)
Peach tree borer (*Synanthedon exitiosa*): 56
Pear leaf blister mite (*Eriophyes pyri*): 29, 30, 61
Pear sawfly (*Caliroa cerasi*): 30, 56
Pear slug (see pear sawfly)
Peashrub (see *Caragana*)
Pentac: 37
Perenial weed control: 69
Perennial nightshade: 69
Perfumed soap (repellent): 68
Permethrin (Ambush): 37
Pest Control Product Act: 6
Pesticides 1-10, 36-38
- Accidents: 2
- Act: 6
- Air application: 7
- Application: 7
- Chemical families: 36
- Clean the sprayer: 75
- Compatibility: 9
- Container disposal 7
- Drift: 7
- Dry flowable: 9
- Exposure: 4
- Acute toxicity: 2
- Toxicity to bees: 8
- Packaging: 9
- Protective clothing: 3-6, 80

- Regulation: 6, 7
- Residues: 8
- Safety: 1-10
- Schedules (1-6): 6, 36
- Sprayers: 7, 73
- Storage: 6
- Water contamination: 1
- Wettable powders: 9

Petunia: 83
pH: 13-15, 20
- Testing: 13
- Soil: 13
- Raising: 14
- Lowering: 15

Phenoxy herbicide: 76
Phenyl carbamate: 82
Pheromone traps: 44, 56, 59, 61
Philadelphus (Mock Orange) pests: 32, 90
Phomopsis juniperova (Juniper blight): 47
Phopalicus sp. (see juniper tip gall midge)
Phosmet (Imidan): 37
Phosphine: 5
Phosphoric acid: 20
Phosphorous sources: 18
Phosphorus requirements of field nursery stock: 17
Phthalimide (Ph): 36
Phyllaphis fagi (see woolly beech aphid): 44
Phylloxera caryaecaulis (see Hickory gall aphid)
Physokermes piceae (see spruce bud scale)
Phytophthora: 33, 58
Picea (spruce) pests: 29, 30, 31, 32, 35, 50, 91
Pieris sp. (Japanese pieris): 90
Pigweed: 93
Pine (see *Pinus*)
Pine bark adelgid (*Pineus strobi*): 52
Pine canker (*Scleroderris abietina*): ... 54
Pine needle scale (*Chionaspis pinifoliae*): 53
Pine root collar weevil (*Hylobius radicis*): 30, 53
Pine sawfly (*Neodiprion sertifer*): 53
Pine shoot beetle (*Tomicus piniperda*): 53
Pine spittle bug (*Aphrophorphora cibrata*): 53
Pine tortoise scale (*Toumeyella numismaticum*): 53
Pine voles (see voles)
Pine webworm (*Tetralopha lecontei*): 30, 54
Pineapple weed: 93
Pineus strobi (see pine bark adelgid)
Pinus (pine) pests: 29, 30, 31, 32, 33, 35, 52, 92
Pirimor: 37
Pissoides approximatus (see Northern pine weevil)
Pissoides strobi (see white pine weevil)
Piston pumps: 74
Pittosporum sp: 92
Plagiodera vericolora (Imported willow leaf beetle): 29, 30, 60
Plant bugs: 26
- Ash plant bug: 45
- Lacebug: 45
- Tarnished plant bug: 63

Plant lice (see aphids)
Plant tissue testing (foliar analysis): ... 13
Plantain: 93
Platanus (London plane, Sycamore) pests: 29, 30, 32, 34, 55, 90
Plum (see *Prunus*)
Podesia syringae var. syringae (Lilac borer): 61
Poison ivy: 94
Poisoned baits: 66-67
Polyram: 37
Polyvinyl alcohol (PVA): 9
Popillia japonica (see Japanese beetle)
Poplar (see *Populus*)
Poplar and willow borer (*Cryptorynchus lapathi*): ... 30, 31, 55
Poplar canker: 55
Populus (poplar) pests: 29, 30, 31, 32, 55, 60, 90
Porosity: 20
Posocarpus sp: 90
Pososesia syringae (see ash borer)
Potash: 14
Potassium requirements for field nursery stock: 17
Potassium sources: 18
Potassium sulphate: 14
Potentilla sp. (cinquefoil): 90
Potting mixes: 19
Pounce: 37
Powdery mildew: 32
- on *Rosa*: 60
- on *Syringa*: 62
- on *Viburnum*: 65

Prickly lettuce: 93
Princep nine-T (see simazine)
Pristiphora erichsonii (see larch sawfly)
Pristiphora geniculata (see mountain ash sawfly)
Privet (see *Ligustrum*)
Frivet rust mite (*Aculus ligustri*): 47
Privet thrips (*Dendrothrips ornatus*): .. 47
Profensua collaris (see hawthorn leafminer)
Profenusa lucifex (oak leaf miner): 57
Propiconazole (Alamo): 37
Propyzamide (Kerb): 85
Proso millet: 95
Protective clothing: 4-5
Prunus (cherry, peach, plum) pests: 30, 31, 33, 34, 56, 90
Pseudococcus cuspidatae (taxus mealy bug): 62
Pseudomonas syringae (Bacterial blight/canker): 44, 56, 60, 62
Pseudotsuga (Douglas Fir): ... 29, 50, 90
Psylla buxi (see boxwood psyllid)
Psyllids: 24, 25
Pulvinaria innumerabilis (see cottony maple scale)
Pumps: 74
Purslane: 93
PVA (polyvinyl alcohol): 9
Pyracantha (firethorn) pests: 57, 90
Pyracantha scab (*Venturia pyracanthae*): 33, 57
Pyrate (chlorpyrifos): 37
Pyrrhalta luteola (see Elm leaf beetle
Pyrus (Pear) pests: 29, 30, 57, 61, 90
Pythium sp*:* 33

Q

Quackgrass: 94
Quercus (oak) pests: 13, 26, 29-31, 32, 57, 90
Quince rust (*Gymnosporangium clavipes*): 43

R

Rabbit control: 67
Ragweed: 93
Ramik brown: 67
Ramik green: 67
Ratak+: 67
Red banded leaf roller (*Agyrotaenia velutinana*): 49
Red clover: 69
Red headed pine sawfly (*Neodiprion lecontei*): 30, 53
Red maple (see *Acer*)
Re-entry after spraying: 3
Repellants:
- Deer: 67
- Rabbit 67

Respirators: 4
Rhizosphaera kalhoffii (spruce needlecast): 52
Rhododendron (azalea, rhododendron) pests: 20, 30, 58, 90
Rhododenron dieback (*Phytophthora* sp.): 58
Rhystima acerinum/*Rhystima punctatum* (Tarspot on maple): 40
Ribes (alpine cranberry): 90
Rival (see trifluralin)
Road salt (see salt damage)
Robinia (locust) pests: 31, 59, 90
Rodent control: 66-68
Rodenticides (R): 36, 37-38, 66, 67
Roller applicator (herbicides): 73
Ronstar (see oxadiazon)
Root circling: 19
Root lesion nematode (*Pratylenchus* sp.): 80
Root rots: 33
Rope-wick applicator (herbicides): 73
Rosa (rose) pests: 26, 30, 32, 34, 35, 59, 90
Rose (see *Rosa*)
Rose chafer (*Macrodactylus subspinosus*): 30, 59
Rose mosaic virus: 35
Rose of Sharon (see *Hibiscus*)
Rose slug/sawfly (*Endelomyia aethips, Allanthus cinctus*): 59
Roundup (see glyphosate)
Rovral: 37
Rozol: 37
Russian olive (see *Eleagnus* sp.)
Russian thistle: 93

Rust: 33
- Cedar-apple rust: 47, 50
- Hawthorn rust: 43, 47
- Quince rust: 47
- Sweet fern blister rust: 55
- White pine blister rust: 55

Rust mite: 26, 46
Ryactonia buolina (see European pine shoot moth)
Rye: 69
Ryegrass: 95

S

Safer's Insecticidal Soap: 37
Safety clothing/equipment: 4-5
Safety supply companies in Ontario: ... 6
Salt conductivity reading: 15
Salts in soil: 15
Salix (willow) pests: 29-31, 60
Sambucus sp. (elderberry): 90
Sawflies: 25
- European pine sawfly: ... 29, 30, 53
- Larch sawfly: 30, 47
- Mountain ash sawfly: 30-31, 61
- Pear sawfly: 30, 56
- Pine sawfly: 29, 30, 53
- Roseslug: 59

Scab: 33
- Apple scab: 33, 50
- Firethorn scab: 33, 57

Scales: 26-27
- Cottony maple scale: 29, 30, 39
- Euonymus scale: 29, 30, 43
- Golden oak scale: 57
- Juniper scale: 30, 46, 63
- Oystershell scale: 30, 45, 49
- Pine needle scale: 53
- Tuliptree scale: 48

Schedule 1-6 Pesticides: 6, 36
Scirrhia sp. (brown spot on *Pinus*): 55
Scleroderris abietina (canker on *Pinus*): 54
Scolytis multistriatis (see European elm bark beetle)
Scorch: 35
Seed beds (fertilizing): 17
Seed treatments: 10
Self contained breathing apparatus: 5
Sevin: 37
Shot hole leaf spot on *Prunus* (*Blumeriella jaapii*): 56
Simadex (see simazine)
Simazine (simazine, simadex): 85
Sircoccus sp. (tip blight of spruce and pine): 52, 54
Sircoccus clavigignenti-juglandacearum (Butternut canker): 33, 46
Skeletonizers: 24
- Apple and thorn skeletonizer: 30,31
- Birch skeletonizer: 29, 41
- Maple trumpet skeletonizer: 40
- Oak skeletonizer: 29, 31, 58

Skoot: 67
Slugs (Snails): 24, 25
Smartweed: 93
Sniper (Guthion, azinphos-methyl): ... 37
Snowball aphid (*Veoceruraphis viburnicola*): 65
Soft scales: 27, 35
Soil
- Acidification: 14-15
- Fertility: 11-23
- Micronutrients: 12-13
- Pests: 27
- pH: 13
- sampling: 11
- sterilization: 28, 79

Soil and Nutrient lab (U of G): 12
Soilless media: 20
Soluble salt (soil): 15, 36
Solubor: 9
Solupak: 9
Sooty mold: 26, 46, 49, 51, 54
Sorbus (Mountain ash) pests: 29-31, 32, 33, 61
Sow thistle: 93
Soybean cyst nematode (*Heterodera glycenes*): 28
Space fumigants: 5
Sphaeropsis sapinea (Diplodia pinea, Diplodia tip blight): 54
Sphaerothecapannosa var. rosae (Powdery mildew on *Rosa*): 60
Spider mites: 26, 29, 30, 47, 49, 51, 59, 63
Spills Action Centre: 2
Spiny elm caterpillar (*Nymphalis antiopa*): 30, 60
Spittle bugs: 25
Spray operation guidelines: 4
Sprayer calibration: 76
Sprayers: 7
Spring cankerworm (*Paleacrita vernata*): ...29, 49, 57, 64
Spring Fertilizer Application: 17
Spruce bud scale (*Physokermes piceae*): 51
Spruce budworm (*Choristoneura fumiferana*): 39
Spruce branch dieback/canker (*Cytospora*, Valsa): 51
Spruce needle miner (*Taniva albolineana*): 30, 51
Spruce spider mite (*Oligonychus ununguis*): 26, 29, 30, 47, 51, 63
Spurge: 93
Stinging nettle: 94
Stinkweed: 93
Stratford Agri Analysis: 12
Strawberry root weevil (*Otiorhynchus ovatus*): 51, 63
S-triazine: 85
Streptomycin sulphate (Agri-Mycin 17): 37
Sucking insects: 26
Sudan grass: 69
Sugar maple borer (*Glycobius speciosus*): 40
Sulfur: 15
Sumac (rose chafer host): 30
Sumithion: 37
Super phosphate: 14, 22
Superior oil: 9
Sweet fern blister rust (*Cronartium comptoniae*): 55
Sweet gale *(Myrica gale*): 55
Sycamore anthracnose (*Gnomonia plantani*): 32
Synanthedon exitiosa (see Peach tree borer)
Synanthedon ictipes (see Lesser peach tree borer)
Synthetic pyrethroid (Syn. Pyr.): 36
Syringa (lilac) pests: 29-30, 61, 90

T

2, 4-D: 69, 72, 75
Taniva albolineana (see spruce needle miner)
Tarspot on maple (*Rhystima acerinum, R. punctatum*): 40
Tarnished plant bug (*Lygus lineolaris*): 63
Taxus mealy bug (*Pseudococcus cuspidatae*): 62
Taxus (yew) pests: 20, 29, 30, 62, 90
Telone: 28
Terr-o-Gass (methylbromide chloropicrin): 81
Tetralopha robustella (see pine webworm)
Tetranychus urticae (see two spotted spider mite)
Thiadiazole (Thia): 36
Thiodan (Endosulfan): 37
Thiophanate methyl (Easout): 37
Thiram-based mixtures: 67-68
Thrips: 25, 26
- Privet thrips: 47

Thuja (arborvitae, cedar) 20, 29-31, 35, 63, 90
Thuricide: 37
Tilia (linden) pests: 26, 29-31, 34, 64, 90
Tip blight of pine and spruce (*Sirococcus* sp.): 52, 54
Toadflax: 94
Tomicus piniperda (see pine shoot beetle)
Toss-N-Go: 9
Touchdown (see glyphosate)
Toumeyella liriodendri (see tuliptree scale)
Toumeyella numismaticum (see pine tortois shell scale)
Toxicity
- Definitions: 2
- Insecticides to honeybees: 8

Transplant liner beds (fertilizing): 17
Tree guards: 66
Triazine: 71, 85
Tribasic copper sulphate (Copper): ... 37
Trichlorfon (Danex, Dylox): 37
trifluralin (Bonanza, Rival, Treflan): ... 87
Tropidosteptes amoenus (see ash plant bug)
Tsuga (hemlock) pests: 26, 30, 64
Tulip tree aphid (*Macrospiphum liriodendri*): 48
Tulip tree (see *Liriodendron*)
Twig pruners: 24

Two spotted spider mite (*Tetranychus urticae*): 26, 30, 49, 59

U

Ugliest caterpillar (*Archips cerasworanus*): 56
Ulmus (Elm) pests: 26, 29-31, 64, 90
Unaccredited soil tests: 11
Unapsis euonymi (see Dutch elm disease)

V

Valsa (*Cytospora*) canker on spruce: 51
Vapam (see metam sodium)
Vasates aceris-crummerna (see maple spindle gall mite)
Vasates quadipes (see maple bladder gall mite)
Vascular wilts: 34
- Ceratocystis (*Ophiostoma*) (Dutch elm disease): 34, 65
- *Verticillium* on maple: 40

Velvetleaf: 93
Vendex: 37
Venturia inaequalis (apple scab): 33, 50
Venturia pyracanthae (Pyracantha scab) 33, 57
Veoceruraphis viburnicola (see snowball aphid)
Verticillium wilt: 34, 40, 64
Vetch: 94
Viburnum (viburnum) pests: 29-31, 65, 90
Viburnum leaf beetle (*Pyrrhalta viburni*): 29, 30, 31, 65
Virginia creeper (see *Parthenocissus*)
Viruses: 34
Vitis sp. (wild grape): 28, 30, 31, 94
Voles: 66
Vorlex: 28, 81
Vorlex plus (methyl isothiocyanante/ dichloropropene): 81

W

Walnut blister mite (*Aceria erinea*): 46
Walnut caterpillar (*Datana integerrima*): 46
Washing protective clothing and equipment: 4
Water holding capacity: 20
Water soluble fertilizers: 21
Water soluble packaging: 9
Webworms: 25, 29, 31, 45, 47
Weeds: 69-95
- Control: 69-95
- Sources of: 70
- Herbicides: 79

Weed susceptibility to herbicides: 93-95
Weevils:
- Black vine weevil: 30, 62
- Strawberry root weevil: 54, 63

White cedar (see *Thuja*)
White pine aphid (*Cinara strobi*): 54
White pine blister rust (*Cronarium ribicola*): 55
White pine weevil (*Pissoides strobi*): 54
Wiegelia sp: 90
Wild buckwheat: 93
Wild grape (see *Vitis*)
Wild oats: 95
Wilts (see Vascular wilts)
Wind and pesticide application: 7
Woolly beech leaf aphid (*Phyllaphis fagi*): 44
Woolly larch adelgid (*Adelges lariciatus*): 47

Y

Yellow headed spruce sawfly (*Pikonema alaskensis*): 30
Yellows: 35

Z

Zimmerman pine moth (*Dioryctria zimmermani*): 54
Zinc in soil: 12
Zinc phosphide (rodent poison): 66
Zineb (Dithane Z-78): 37

Colour Plates

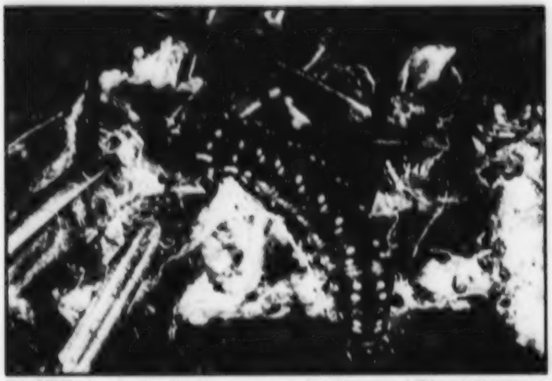

PLATE 1. Late instar spruce budworm (*Choristoneura fumiferana*) larva.

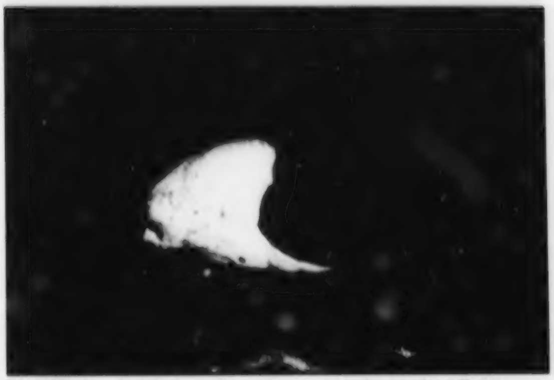

PLATE 2. Adult female cottony maple scale (*Pulvinaria innumerabilis*) with cottony mass of eggs.

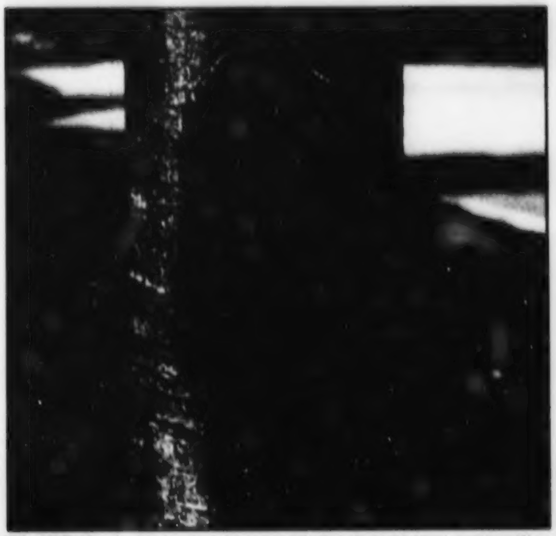

PLATE 3. Late instar larvae of the forest tent caterpillar (*Malacosoma disstria*).

PLATE 4. Adult female scale of European fruit lecanium (*Lecanium corni*).

PLATE 5. Leaf webbing and feeding damage caused by the maple trumpet skeletonizer (*Epinotia aceriella*).

PLATE 6. Tar spot (*Rhystima acerinum, R. punctatum*) lesions on *Acer platanoides*, early August.

PLATE 7. *Verticillium* (V. *dahliae*, V. *albo-atrum*) wilt staining on heartwood (xylem) of *Acer* sp.

PLATE 8. Leaf blotch (*Guignardia aesculi*) on *Aesculus* sp., July.

PLATE 9. Mines on leaves caused by the birch leaf miner (*Fenusa pusilla*) in late May.

PLATE 10. Larval tunnels of bronze birch borer (*Agrilus anxium*). The tunnels circle the trunk, causing raised "vein"-like swellings in bark.

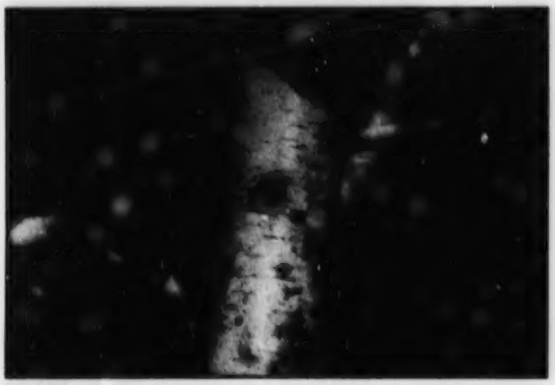

PLATE 11. "D"-shaped exit hole in bark caused by bronze birch borer (*Agrilus anxium*).

PLATE 12. Late instar larva of Gypsy moth (*Lymantria dispar)*. Note 5 pairs of blue dots followed by 6 pairs of red dots along back.

PLATE 13. Adult female Gypsy moth (*Lymantria dispar*) depositing brown, fuzzy egg mass on tree trunk, early August.

PLATE 14. Hawthorn rust (*Gymnosporangium globosum*) on *Crataegus* sp., August. Aecia releasing aeciospores, these spores can infect alternate host, *Juniperus*.

PLATE 15. Quince rust (*Gymnosporangium claviceps*) on *Crataegus* sp., August. Aecia releasing aeciospores, these spores can infect alternate host, *Juniperus*.

PLATE 16. *Septoria* leaf spot on *Cornus* sp., August.

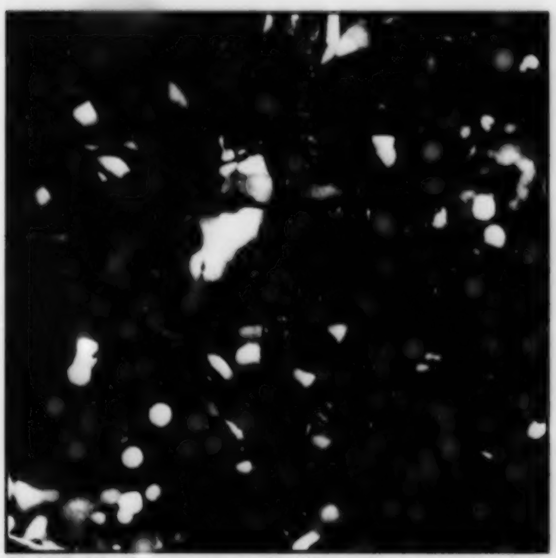

PLATE 17. Euonymus scale (*Unaspis euonymi*) adults appear as white, oblong scales on twigs.

PLATE 18. Euonymus webworm (*Yponomeuta cognatella*) larvae feeding, June.

PLATE 19. Fall webworm (*Hyphantria cunea*) larvae feeding at end of branches, August.

PLATE 20. Anthracnose (*Gloeosporium aridum*) on ash causing twisted leaves with lesions at the tip.

PLATE 21. Honeylocust mite (*Eotetranychus multidigituli*) causing stippled bronzing on foliage.

PLATE 22. Adult juniper scale (*Carulaspis juniperi*) on foliage.

PLATE 23. Cedar-apple rust (*Gymnosporangium juniperi-virginianae)* overwintering gall on juniper foliage, not sporulating, March.

PLATE 24. Cedar-hawthorn rust (*Gymnosporangium globosum*) overwintering gall on juniper foliage, not sporulating, March.

PLATE 25. Juniper dieback or tip blight (*Phomopsis juniperovora*) on juniper.

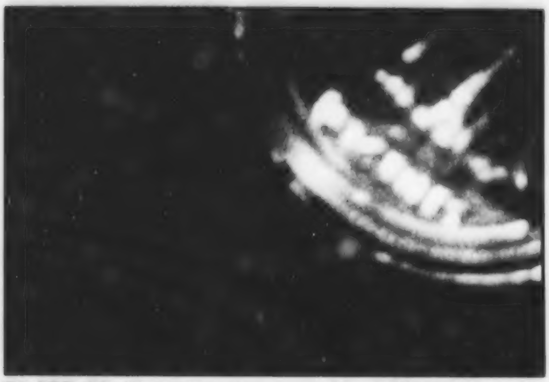

PLATE 26. Overwintering nymphs of Magnolia scale (*Neolecanium cornuparvum*) on the twigs of magnolia, early May.

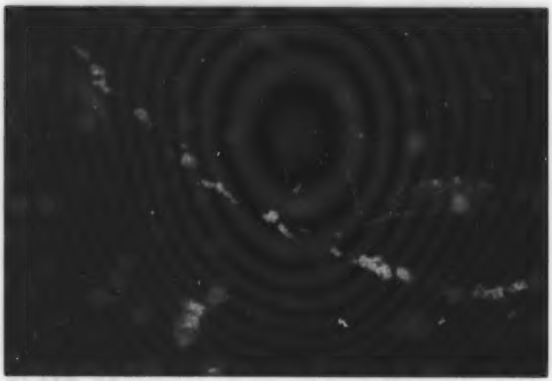

PLATE 27. Immature females of Magnolia scale (*Neolecanium cornuparvum*) on the undersides of twigs, July.

PLATE 28. Large aphid colony on *Malus* sp.

PLATE 29. Fall cankerworm (*Alsophila pometaria*) larvae.

PLATE 30. Spring cankerworm (*Paleacrita vernata)* larva.

PLATE 31. Eastern tent caterpillar (*Malacosoma americanum*) larvae with a stripe along their back.

PLATE 32. Leafhopper "burn" or stippled foliage on *Ptelea* sp.

PLATE 33. Fireblight (*Erwinia amylovora*) on *Malus* sp.

PLATE 34. Apple scab (*Venturia inequalis*) on *Malus* sp.

PLATE 35. Cooley spruce gall (*Adelgies cooleyi*) formation on *Picea pungens* shoot tip, June.

PLATE 36. Cooley spruce gall adelgids (*Adelgies cooleyi*) feeding on *Pseudotsuga menziesii*, the alternate host, in May.

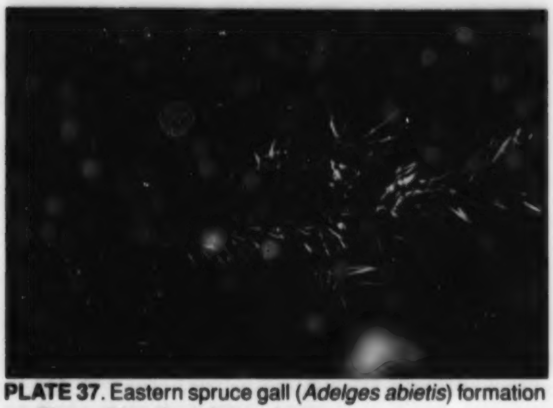

PLATE 37. Eastern spruce gall (*Adelges abietis*) formation on *Picea abies* shoot base, June.

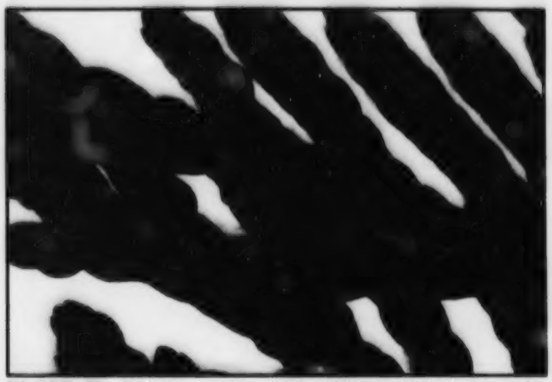

PLATE 38. Spruce spider mite (*Oligonychus ununguis*) feeding damage on *Thuja occidentalis*, September.

PLATE 39. Spruce needle miner (*Taniva albolineana*) feeding damage on *Picea* sp.

PLATE 40. *Cytospora* canker on *Picea*.

PLATE 41. *Rhizospaera* needlecast on *Picea*, June.

PLATE 42. Feeding damage on emerging shoots caused by European pine shoot moth (*Rhyacionia buoliana*), May.

PLATE 43. Feeding damage on *Pinus* by adult Pales weevil (*Hylobius pales*), September.

PLATE 44. Masses of pine bark adelgid (*Pineus strobi*) on the bark of *Pinus* in May.

PLATE 45. Adult pine needle scale (*Chionaspis pinifoliae*) give a whitish appearance to foliage of *Pinus*, May.

PLATE 46. Adult female pine needle scale (*Chionaspis pinifoliae*) with red crawlers, in June.

PLATE 47. Pitch masses on bark of *Picea* due to feeding of pine pitch mass borer (*Vespamima pini*).

PLATE 48. Pinkish white larva of pine pitch mass borer (*Vespamima pini*) extracted from a pitch mass.

PLATE 49. European pine sawfly larva (*Neodiprion sertifer*).

PLATE 50. Redheaded pine sawfly larvae (*Neodiprion lecontei*).

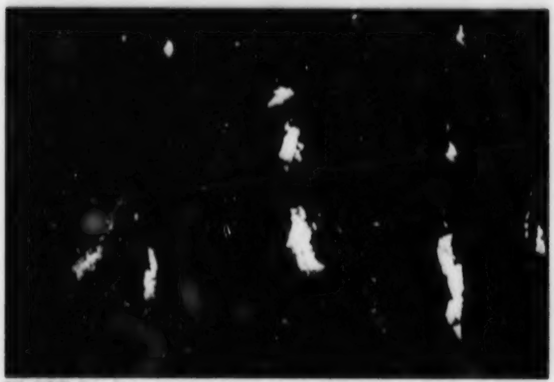

PLATE 51. Egg laying sites (sap streaks) in bark of *Pinus sylvestris* by the pine shoot beetle (*Tomicus piniperda*), in early spring.

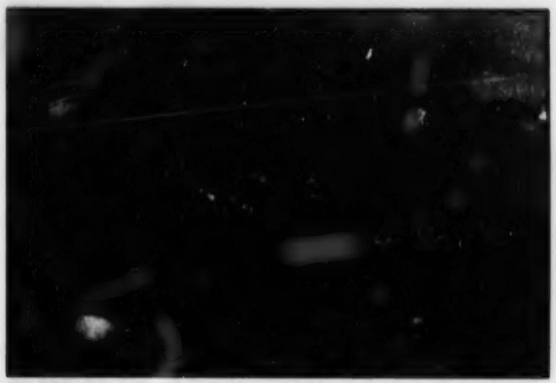

PLATE 52. Larval feeding galleries of pine shoot beetle (*Tomicus piniperda)* formed under bark of *Pinus sylvestris*.

PLATE 53. Flagged/broken tip on *Pinus* sp. due to shoot feeding of adult pine shoot beetle (*Tomicus piniperda*).

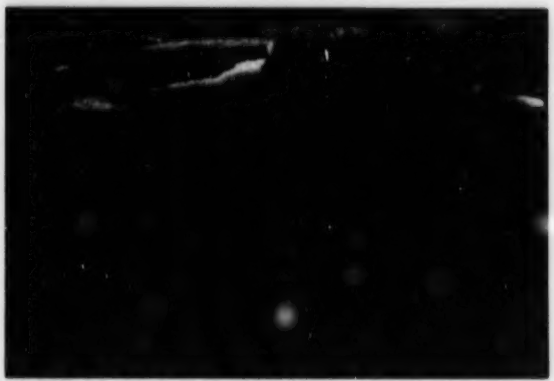

PLATE 54. Adult pine shoot beetle (*Tomicus piniperda*) boring out a clean hole in the shoot tip of *Pinus* sp.

PLATE 55. Feeding damage on terminal caused by white pine weevil (*Pissodes strobi*).

PLATE 57. Stunted, dead new growth on *Pinus nigra* caused by *Diplodia* tip blight, June.

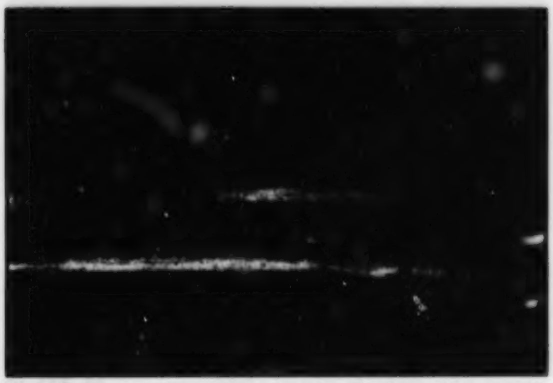

PLATE 56. Legless, white larvae of white pine weevil (*Pissodes strobi*) found inside terminal in June.

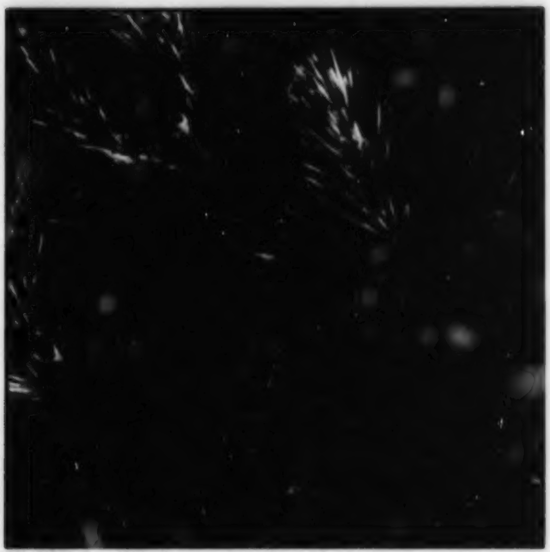

PLATE 58. Killed pine needles of previous year's growth due to *Lophodermium* needlecast.

PLATE 59. Canker on main stem of white pine blister rust (*Cronartium ribicola*).

PLATE 60. Damaged limbs of *Prunus* sp. by boring larvae of lesser peachtree borer (*Sunanthedon pictipes*).

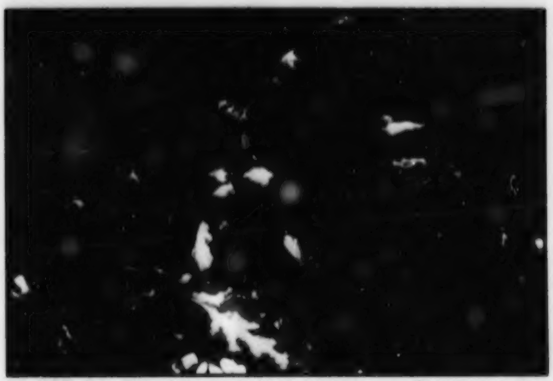

PLATE 61. Physiological leaf scorch on *Quercus rubra* caused by heat and drought stress.

PLATE 62. Feeding damage on *Vitis* sp. caused by Japanese beetle (*Popillia japonica*).

PLATE 63. Adult Japanese beetle (*Popillia japonica*), dorsal and ventral view. Note tufts of white hairs around abdomen.

PLATE 64. Black spot (*Diplocarpon rosae*) lesions on *Rosa* sp. foliage.

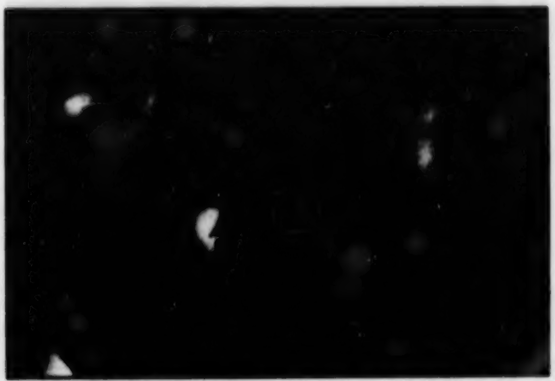

PLATE 65. Exit hole from emerging adult lilac borer (*Podesia syringae*), June.

PLATE 66. Leaf blotches caused by feeding damage of lilac leafminer (*Caloptilia syringella*), June.

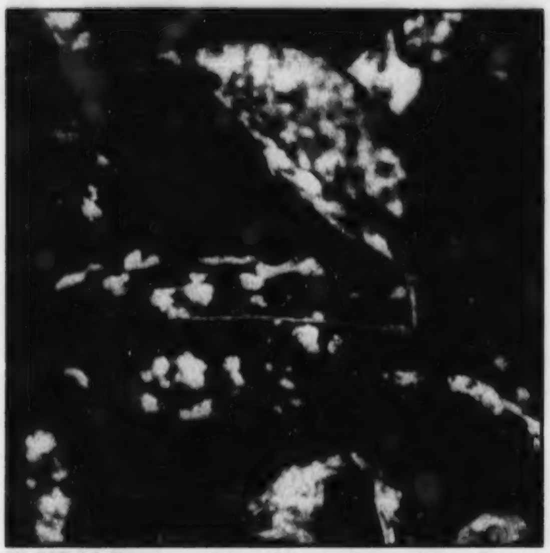

PLATE 67. Powdery mildew (*Microsphaera alni*) on *Syringa* sp.

PLATE 68. Notches in leaves of *Rhododendron* caused by feeding of black vine weevil (*Otiohynchus sulcatus*).

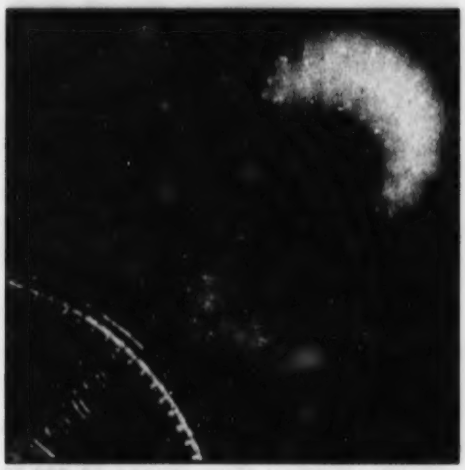

PLATE 69. Legless, white larvae of black vine weevil (*Otiohynchus sulcatus*), sitting against a Canadian dime.

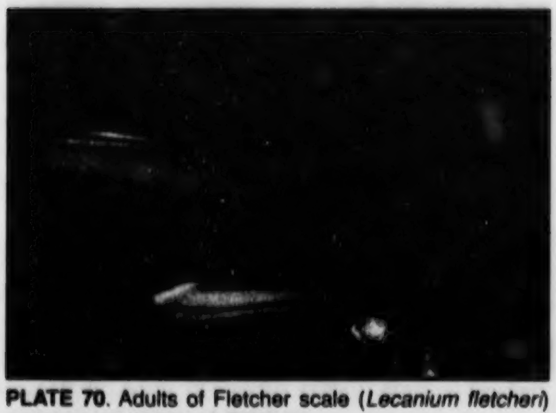

PLATE 70. Adults of Fletcher scale (*Lecanium fletcheri*) on twigs and leaves of *Taxus* sp.

PLATE 71. Nymphs of *Taxus* mealybug (*Pseudococcus cuspidatae*) on twigs, May.

PLATE 72. Foliar tip browning caused by feeding of cedar leaf miner (*Argyresthia thuiella*), June.

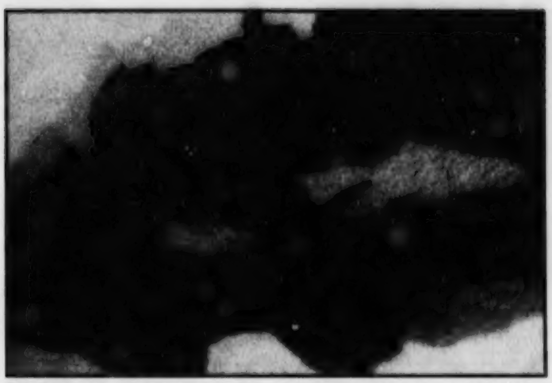

PLATE 73. Foliar bronzing and some twig bark stripping on *Thuja occidentalis* caused by strawberry root weevil (*Otiorhynchus ovatus*) adults.

PLATE 74. Adult tarnish plant bug (*Lygus lineolaris*).

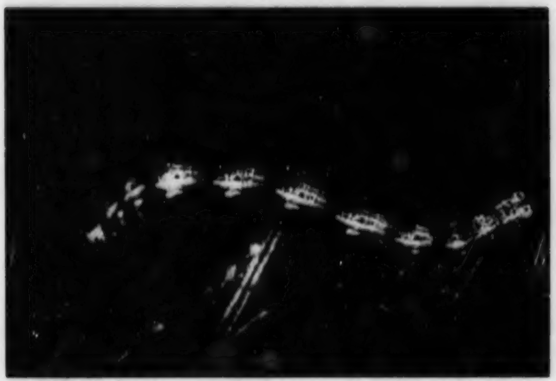

PLATE 75. Eastern hemlock looper (*Lambdina fiscelleria*) larva.

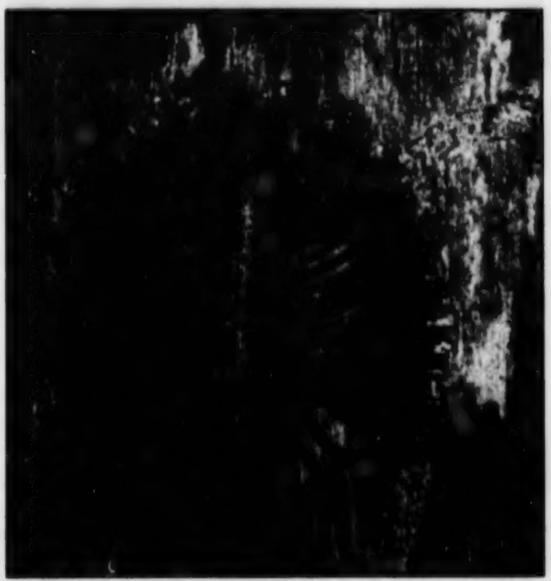

PLATE 76. Larval gallery of elm bark beetle (*Scolytus multistriatus, Hylurgopinus rufipes*) in cambium.

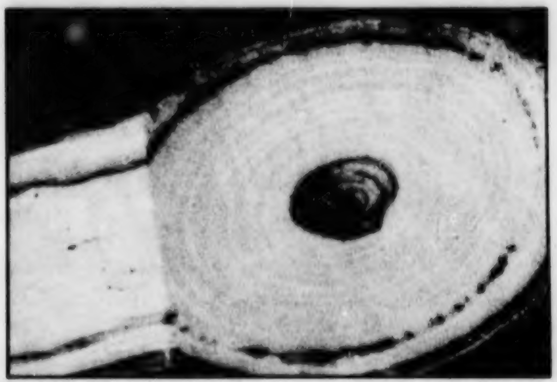

PLATE 77. Infection of xylem by Dutch elm disease (*Ceratocystis ulmi*) causes stained rings in wood.

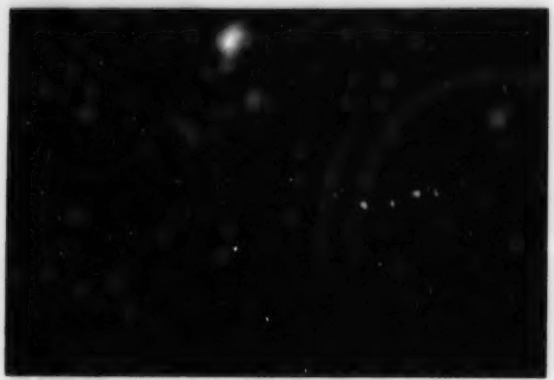

PLATE 78. Viburnum leaf beetle (*Pyrrhalta viburni*) larva, May.

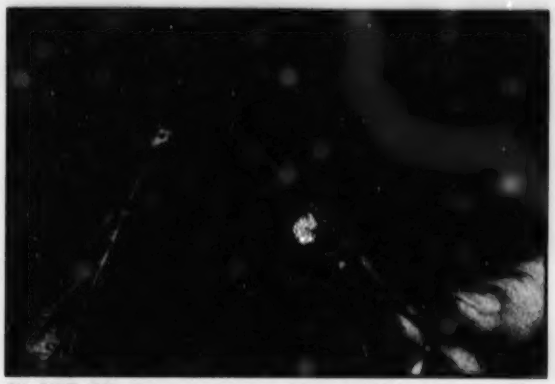

PLATE 80. Overwintering egg-laying sites (on twig undersides) of Viburnum leaf beetle (*Pyrrhalta viburni*), August.

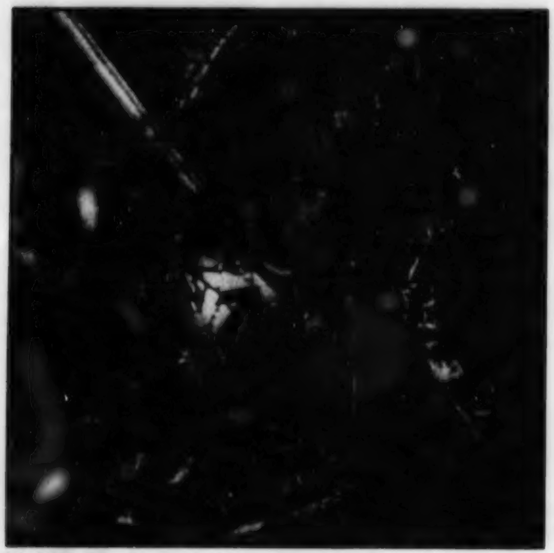

PLATE 79. Skeletonizing damage due to feeding of Viburnum leaf beetle (*Pyrrhalta viburni*) larvae, June.

The photos on the previous pages were provided by the University of Guelph, Agriculture and Agri-food Canada, and the Ontario Ministry of Agriculture, Food and Rural Affairs.

Emergency and First-Aid Procedures for Pesticide Poisoning

- Become familiar with the chemicals you are using. Keep a list of common names in case of accidents or emergencies. This information can be found on the product labels and cross-referenced in this publication.
- If a pesticide has come in contact with the skin or has been spilled on clothing, remove the clothing and wash the skin thoroughly with soap and warm water.
- If pesticide has come in contact with the eyes, rinse them with plenty of clean water for 15 minutes. Repeat this procedure.
- If a person suspects poisoning from exposure to a pesticide by swallowing, inhalation, or contact with skin or eyes, read the label on the pesticide container and carry out the first-aid treatment suggested.
- **Immediately after first-aid treatment has been given, wrap the patient in a coat or blanket and rush him/her to the nearest hospital. Take the list of chemical common names with you and identify the ones being used.**
- **If a person is unconscious or lapses into unconsciousness, call an ambulance immediately.**
- **Emergency advice on pesticide poisoning is available from the Regional Poison Information Centres at:**

  Toronto 1-800-268-9017 Ottawa (bilingual) 1-800-267-1373

- **Those needing hearing assistance should call: 1-416-597-0215 (TTY)**

  Emergency telephone numbers are listed at the front of each Bell telephone directory.

  Fill in the following:

  My Local Poison Information Centre Telephone Number is:

  _____-________________________________

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